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COVER SHEET
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Title: Data Modeling and Sharing Perspective for Development of a Common Operating Picture

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Abstract:
This report documents analyses that were performed in support of Task #3 of Work Package #3 (WP3), "ROA Impact on the NAS". The purpose of the overall work package was to determine if there are any serious issues that would prevent or prohibit ROA's flying in the NAS on a routine basis, and if so, what actions should be taken to address them. The purpose of Task #3 was to look at this problem from the perspective of data modeling and sharing.

Specific areas of investigation were:

ROA impact on the NAS from a data model and sharing perspective. Answer the questions:
- → Will any ROAs be incapable of providing any required information to the ATC or other agents?
- → Are there any latency issues?
- → Will new types of information be required?
- → Will ROAs have to add equipment to process data associated with potential new procedures or operations?

NAS modernization. Analyze the data modeling and sharing aspects of proposed future changes to the NAS, and determine whether or not these are compatible with ROA operations. This includes, but is not necessarily limited to:
- →NAS Architecture version 6,
- →Operational Evolution Plan (OEP),
- →Target System Description (TSD),
- →System Wide Information Management (SWIM) architecture.

Enterprise architecture frameworks. Investigate the interoperability of information system architectures that were or might be produced using the enterprise architecture framework approach:
- →Federal Enterprise Architecture Framework (FEAF)
- →Department of Defense Architecture Framework (DODAF), formerly Command, Control, Communication, Computers for Information, Surveillance and Reconnaissance (C4ISR).

Data schemas. Analyze and compare proposed data "schemas" being proposed by the US NAS and the European air traffic management systems.

Status:

SEIT-Approved

Limitations on use:
A major portion of the effort was devoted to development of the spreadsheet of information (voice and data) flows in the NAS. This was accomplished via several brainstorming sessions, considering that no such spreadsheet could be found in literature, at the desired high functional level. Note that, although quite a bit was accomplished in the construction of this spreadsheet, there is still some work left to make it complete and consistent. It could also benefit from a thorough review by domain experts (pilots and controllers, for example).

Remotely Operated Aircraft (ROA) Impact on the National Airspace System (NAS) Work Package

Data Modeling and Sharing Perspective for Development of a Common Operating Picture

The following document was prepared by a collaborative team through the Implementation and Infrastructure work package. This was a funded effort under the Access 5 Project.

RECORD OF CHANGES

Revision	Date	Action
0.1	TBD	TBD

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EXECUTIVE SUMMARY

This report documents analyses that were performed in support of Task #3 of Work Package #3 (WP3), "ROA Impact on the NAS". The purpose of the overall work package was to determine if there are any serious issues that would prevent or prohibit ROA's flying in the NAS on a routine basis, and if so, what actions should be taken to address them. The purpose of Task #3 was to look at this problem from the perspective of data modeling and sharing.

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<u>Data schemas</u>. Analyze and compare proposed data "schemas" being proposed by the US NAS and the European air traffic management systems.

The table below summarizes the progress that was made (or not made) on these goals.

ROA Data Needs Impact	Architecture Analysis	Enterprise Architecture Framework Analysis	US vs. European Data Schema Comparison
Spreadsheet of data flows in the NAS was developed with ROA-specific impacts noted.	Analyzed Administrator's Flight Plan, NAS Architecture, OEP, TSD. Also a cursory look at SWIM.	Thorough investigation into history and similarities & differences among enterprise architecture frameworks.	Initial look only. Needs further investigation and consultation with domain experts.

A major portion of the effort was devoted to development of the spreadsheet of information (voice and data) flows in the NAS. This was accomplished via several brainstorming sessions. We decided to construct our own since no such table could be found in the literature, at least at the desired high functional level. Note that, although quite a bit was accomplished in the construction of this spreadsheet, there is still some work left to make it complete and consistent. It could also benefit from a thorough review by domain experts (pilots and controllers, for example).

The premise of this exercise was to establish what information flows currently exist, and to assess whether or not there are any implications for ROAs. The result was a list of several "heads up" items. Not all of these pose a significant problem. It is more a matter of raising awareness about potential problems before they do become a limit to operational capability.

- Primary radar returns (ROA is too stealthy to register),
- Secondary radar returns (equipage issue, i.e., will ROA carry transponder?),
- Voice/data communications between the AVCS pilot and the ATC controller (latency),
- Data communications between the AVCS pilot and the ROA (latency),
- Weather awareness (configuration of AVCS compared to manned flight deck vis-a-vis weather displays),
- Terrain and obstacle avoidance (equipage issue – will EGPWS be installed?)
- Pilot reports (how to "feel" turbulence and "see" weather to report to ATC?),
- Future navigation capabilities (equipage issue with respect to RNAV, RNP),
- Collision avoidance (for example, TCAS is currently disallowed for ROAs in restricted airspace).
- Equivalent level of safety (what new on-board and/or off-board systems, and hence new data flows, will be required)
- Surface movement situational awareness (equipage issue – will ROAs have transponders to cooperate in multi-lateration-based surface position awareness procedures?).

The enterprise architecture framework task consumed the next largest portion of energy on this activity. The main conclusion was that these are *frameworks*, not actual *architectures*, and although they are used to develop architectures, they themselves cannot be judged as *interoperable* or not. Their methodologies can be compared, however. A comparison between the civilian Federal Enterprise Architecture Framework (FEAF) and the military Department of Defense Architecture Framework (DODAF) is provided in this document. It turns out that, although not identical, they have many similarities, as they are based on very similar notions that are encapsulated in the so-called Zachman framework.

However, although the military has developed architectures using DODAF (or its predecessor, Command, Control, Communications, Computers Information Surveillance & Reconnaissance (C4ISR)), not much has been done on the civilian side with FEAF. Therefore, actual determination of interoperability of military and civilian architectures produced by these frameworks was not possible.

Finally, some investigation into future NAS architectures (NAS Architecture V. 5, OEP V. 6, TSD, SWIM) and into data schema comparisons were made. The potential effects of new operational concepts on information flows were noted, but these are two areas that would benefit from more work.

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1 INTRODUCTION

This report documents the analyses that were performed in support of Task #3 of Work Package #3 (WP3), "ROA Impact on the NAS". The purpose of the overall work package was to determine if there are any serious issues that would prevent or prohibit ROA's from flying in the NAS on a routine basis, and if so, what actions should be taken to address them. The purpose of Task #3 was to look at this problem from the perspective of data modeling and sharing.

For the reader who is unfamiliar with the National Airspace System (NAS), please refer to APPENDIX C: Basics of the NAS.

1.1 Background

Access 5 is a national project sponsored by NASA, with participation by the Federal Aviation Administration (FAA), Department of Defense (DoD), and industry, to introduce civil High Altitude, Long Endurance (HALE) ROA to routine flight in the NAS. Access 5 commenced in May 2004 and is slated to run for five or more years.

The goal of Access 5 is to assist in the development of policies and procedures, demonstrate the enabling technologies, and identify infrastructure to promote a robust civil market for HALE ROA. Access 5 will address ROA airworthiness certification, flight operations, and crew certification. Project efforts will also include the development of appropriate standards, working where appropriate, through existing national standards groups. The project products are policy and procedure recommendations on ROA system airworthiness certification, ROA flight operations, ROA pilot certification, and appropriate standards. The project will identify mature technologies in several areas, including conflict avoidance and communications, and will also provide recommendations on maintenance for continued airworthiness, currency for pilots, and guidelines/processes for safe operation.

Access 5 plans call for integrating HALE ROA into the NAS through a four-step process:

Step 1: Routine operations of HALE ROA above Flight Level (FL) 400 (40,000 feet) with restrictions.

Step 2: Routine operations above FL180 (18,000 feet) with restrictions.

Step 3: Routine operations above FL180 and access to ROA designated airports with emergency landings in restricted areas.

Step 4: Routine operations above FL180 and access to ROA designated airports, including emergency landings (i.e., true "file-and-fly").

1.2 Document Organization

Section 1 describes the Access 5 project in order to provide context for the analysis in this document.

Section 2 outlines the goals, scope and approach of this activity. Four areas were chosen for investigation: information flows in the NAS, NAS modernization, data schemas, and enterprise architecture frameworks.

Section 4 provides the results and conclusions in the four areas of investigation. Several areas of potential ROA-information flow interaction were identified. Data-related aspects of NAS modernization, data schemas and enterprise architecture frameworks are discussed.

Links to the appendices can be found below. APPENDIX A: Data Flows in the NAS Spreadsheet contains the main product of this activity. APPENDIX F: References has hyperlinks to many Internet websites that were used to produce this document.

APPENDIX A: Data (Data flows in the NAS together with associated function, network, people, timing and motivation)

APPENDIX B: Current NAS Sensors and Systems and Data Attributes (Connects specific hardware to data traffic and format).

APPENDIX C: Basics of the NAS (A primer on how the NAS works, from the FAA website)

APPENDIX D: Definitions (Defines terms and acronyms used in this document)

APPENDIX E: Acronyms

APPENDIX F: References

2 Goals and Approach

2.1 Goals

Specific areas of investigation were:

ROA impact on the NAS from a data model and sharing perspective. Answer the questions:

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2.2 Scope

For the most part, the analysis of ROA impact on the NAS from the data perspective is confined to current operational procedures and technologies in the NAS. However, there was some consideration given to the possible ramifications from procedures or technologies that are part of the FAA's plan for NAS modernization, such as Area Navigation (RNAV), Required Navigation Performance (RNP), and Automatic Dependent Surveillance-Dependent (ADS-B).

The other analysis areas (NAS modernization, enterprise architecture frameworks, and data schemas) naturally involve discussion of the future information environment in the NAS.

The geographical scope was confined to the US National Airspace System (NAS), except for the comparison of data schemas, since the direction of data definition and management standards is already being influenced by European developments.

2.3 Approach

An extensive literature search was performed in order to gather information on the data flows in the NAS, NAS information architectures present and future, enterprise architecture frameworks, and US and European work in data object standardization. The results of these four investigations are summarized below.

3 Results of Investigation and Analyses

3.1 Data Flows in the NAS

Unfortunately, an existing description of data flows in the NAS from a *high-level functional view* was not found. As a result, a significant portion of the work on Task #3 was directed to developing such a description. This effort involved many hours of brain-storming among domain experts in meetings, telecons, private phone calls and e-mails, and discussions with co-workers. The result can be seen in APPENDIX A: Data Flows in the NAS Spreadsheet.

In this table, data items are organized into nine categories:

- Weather,
- Surveillance,
- Strategic Flight Management,
- Tactical Flight Management,
- Flight Control,
- Aeronautical,
- ATM Resource Management,
- Operator Flight Recording, and
- ATC Flight Recording.

Associated with each data item are the attributes of

- Function(s) that the data supports (what),
- Sequence of system nodes the data flows through (how),
- Transmission mode (also part of how),
- People involved in the production, transmission or use of the data (who),
- Automated systems that produce, process or use data (also part of who)
- Timeliness of the data (when), and
- Motivation for its use (why).

Here is an example entry from the Flight Management table:

Data	**Function**	**Network (Flow)**	**Transmission Mode**	**People**	**Automated Systems**	**Time**	**Motivation**	**Remarks**
Flight object (flight profile, plan)	Planning (commercial strategic)	AOC <--> Service provider	Telephone or electronic	Flow planners, AOC	Operator and HOST computers	Pre-departure planning up to push-back clearance request	Efficiency (service provider); Meet demand (airline)	Flight object could be generated well in advance and populated as flight time approaches.

Note that voice communications were treated as "data" for the purposes of this study. Voice messages were organized according to content or purpose, and placed in the appropriate data category, or categories. For example, pilot-controller communication involving clearances appears in both the Surveillance category and the Flight Control category. It appears in the Surveillance category because it helps increase situational awareness of other pilots through the "party-line" effect. It appears in the Flight Control category as well because it serves to refine, or perhaps modify, the ROA flight plan.

Here as an entry from the Surveillance table:

ata	Function	Network (Flow)	Trans-mission Mode	People	Automated Systems	Time	Motivation	Remarks
ntroller - ot arance mmun-tion	Situational awareness	Pilot(s) <--> Controller(s)	VHF, UHF	Pilots, controllers	NA	Seconds to minutes	Safety (air vehicle)	Other pilots listen in on "party line" for information on nearby aircraft

Here is the corresponding entry from the Flight Control table:

:a	Function	Network (Flow)	Trans-mission Mode	People	Automated Systems	Time	Motivation	Remarks
troller - t rance mun-ion	Flight management; maintain separation	Pilot(s) <--> Controller(s)	VHF, UHF	Pilots, controllers	NA	Seconds to minutes	Safety (air vehicle)	Pilots modify the flight path based on clearance

(Note: Extensive tables linking data flows to *hardware* do exist. For example, see APPENDIX B: Current NAS Sensors and Systems and Data Attributes , a table lifted from Ref. [4].)

3.2 NAS modernization

Using information provided by the FAA website, various initiatives under the NAS modernization plan (NAS Architecture Version 5, OEP Version 6, TSD, Administrator's Flight Plan, and SWIM) were examined to assess their potential for promoting interoperability and a common operating picture for all agents in the system.

None of the programs that were analyzed for this document discuss ROA's in any detail. The best that could be done was to study the various modernization programs and look for any mention of information system architectures and data standards or sharing, and surmise if there would be any implications for ROAs.

There is a wide range of detail in these initiatives. The Administrator's Flight Plan is basically a set of goals. The NAS Architecture Version 5.0 is high level initiative which includes the more detailed Operational Evolution Plan (OEP) and the much more detailed Target System Description (TSD), which is designed to implement the RTCA operational concept for 2015. The System Wide Information Management (SWIM) is another initiative whose goal is develop a global information architecture that provides tailored information to all agents in a timely, efficient, safe and secure way.

3.2.1 FAA Administrator's Flight Plan 2004-2008

This is a declaration of high-level goals of FAA for the next four years in the areas of capacity, safety, international leadership and organizational excellence. Although some references are made to technologies such as ADS-B/TIS-B, NAV, RNP, and WAAS, there are no detailed discussions of information architectures that include data needs or formats. For more details, see Ref. [7].

3.2.2 NAS Architecture Version 5

Architecture 5 is a comprehensive plan for improving the NAS and reaching the Target System Description (TSD).

From Ref. [9]:
"The NAS Architecture, the FAA Strategic Plan, the NAS Operation Evolution Plan (OEP), the NAS Capital Investment Plan (CIP) and the National Aviation Research Plan (NARP) are key NAS modernization plans. Closely linked, each serves a specific purpose. The NAS Architecture is the agency's 15-year plan for modernization, supporting safety, security, and system efficiency goals. This plan establishes objectives and strategies for each goal and identifies related projects. The Architecture includes projections of all expenditures, including research, operations, F&E, and user investment. The FAA Strategic Plan, realized by the NAS Architecture, details FAA goals, establishes objectives and strategies for each, and identifies related projects. The OEP is the agency's commitment to the aviation industry for the next 10 years, addressing capacity and demand issues. The OEP, a subset and refinement of the Architecture, includes all expenditures, and has moved from funding projection to commitment. The CIP is the agency's 5-year F&E plan linked to FAA performance goals. The NARP describes FAA research plans, including those in partnership with other government agencies and private resources, for a 5-year period. These plans are consistent; they complement each other with increasing levels of detail relating to execution of FAA commitments."

3.2.3 OEP Version 6

The following is taken from Ref. [8]:

"The Operational Evolution Plan (OEP) is the Federal Aviation Administration (FAA) ten-year plan to increase the capacity and efficiency of the National Airspace System (NAS) while enhancing safety and security. The commitments and decisions in the OEP have emerged from a close collaboration with the entire aviation community including the airlines, cargo carriers, airports, manufacturers, general aviation, the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA).

Modernizing the NAS is continuous, evolutionary and multi-faceted. The OEP is a "living" document that matures over time. The OEP only contains capacity and efficiency-related programs that can be accomplished in a ten-year timeframe and with each version the timeframe rolls forward one year. Updates may occur as decisions are made, risks are identified and mitigated, or research discovers new solutions to

operational problems.

The OEP started as a business planning activity that accelerated during the summer delays and cancellations of August 2000 that were primarily due to dramatic increases in the number of people flying and particularly bad weather that summer. An FAA plan to address capacity and delay issues, developed in concert with the aviation community, was put in place in Spring 2001. FAA executives had also begun meeting in late 2000 to discuss a broader strategy to address capacity issues and to continue to get input from the aviation community. This OEP Executive Team identified four core problem areas, or quadrants:

Arrival/Departure Rates
En-Route Congestion
Airport Weather Conditions
En Route Severe Weather

Technical teams developed "smart sheets" including key activities, decisions and milestones, for solutions in each of the four quadrants. A senior FAA executive was assigned then and continues to serve as the single Point of Delivery (POD), accountable along with a cross-agency support team for the delivery of products and services detailed in each smart sheet.

Version 3.0 of the OEP was released on June 5, 2001, with an Executive Summary, program details and a chart assigning responsibilities to the FAA, airlines and airports. To oversee the implementation of the OEP, to manage the inter-dependencies of the solutions sets and to coordinate with the aviation community, the FAA established the Operational Evolution Staff in late Spring 2001 (202-385-4900). Version 4.0 was released on December 19, 2001, with expanded descriptions of milestones and major decisions. Version 5.0 was presented at an Industry Day on December 9, 2002, with greater detail of key activities and more alignment to accepted visions for the aerospace industry. Version 6.0 was presented at an Industry Day on December 8, 2003, with discussion centered around the establishment of the Air Traffic Organization, and how it and the OEP will move forward. Speakers at this Industry Day included the Administrator, Marion Blakey, and the ATO Chief Operating Officer, Russ Chew, as well as Vice President of Planning, Steve Brown, the PODs, and industry representatives."

3.2.4 Target System Description (TSD)

The TSD is a view into the Architecture for the year 2015. TSD is based on the joint FAA and industry operational concept for planning and conducting flights with greater safety, flexibility, and efficiency.

In Ref. [10]:
"The Target System Description (TSD) provides a picture of the systems and facilities that will comprise the NAS Architecture when the current "National Airspace System

Concept of Operations and Vision for the Future of Aviation" (CONOPS) is achieved. A preview of the target implementations in the 2012 to 2015 timeframe will identify the extent of evolution of each air traffic service, capability, system, people, and support activities that will be in place to meet the TSD or CONOPS requirements."

3.2.5 SWIM

The FAA definition of SWIM from Ref. [11] is:
"Initiative to provide a common context for top-down, performance-oriented, secure integration and management of shared information assets across the global Air Traffic Management domain."

From Ref. [1]:
"… the **information object** is the basic unit of information management within the SWIM. It is created by publisher members, disseminated to subscriber members and can be archived to support future queries.

… a **common data model** in SWIM is a NAS-wide pre-defined and agreed upon definition of data structures (organized NAS data hierarchies) that make NAS information understandable by all SWIM members. A common data model agreed to by the entire SWIM user community is designed and information objects are derived based on the model. The structural information of the common data model is captured by the metadata in an information object. A data element such as a date has many different representations in today's NAS, the FAA has already established an FAA Data Registry (FDR) that lists approved data standards in FAA-STD-060 format. Standardized data items have been listed with a preferred name, an identifier, data type (e.g., "string"), a definition, permissible values with value meanings, interchange format, maximum length, and unit of measure with minimum and maximum values where applicable. Each standard data element is listed with a steward organization, such as the FAA's Aeronautical Information Division, ATA-100."

3.3 Data schemas

FAA and Eurocontrol websites were searched for current and future methods for data handling in the US and European airspaces, respectively. Additional information was gathered from discussions with domain experts in the area of communication architectures and protocols currently competing for dominance in both the US and Europe.

Currently, there is no global data standard for all aeronautical information. In Europe, Eurocontrol has created a data model called the Aeronautical Information Exchange Model (AIXM) intended for use throughout European airspace. The FAA does have initiatives with Eurocontrol (as well as with CAAs in the Americas) to help drive agreement on a global data model. See Ref. [6].

On the FAA side (Ref. [14]):

"The FAA has invested in an Oracle-driven tool that is known as the FAA Data Registry (FDR). The FDR will hold metadata, or data about the operational data, that defines and describes those data elements to the format level. The FDR is built and will be managed to industry standards, the International Standards Organization (ISO)/International Electrotechnical Commission (IEC) Standard 11179, Specification and Standardization of Data Elements. Though the information and data flows in the NAS are extensive with significant interoperability concerns, there are identifiable data elements that constitute the core operational data that will be the initial focus of a standardization effort. Currently, the NAS interoperability issues present a substantial risk to modernization efforts. It is expected that standard data will greatly mitigate the technical and programmatic risks associated with acquiring new systems for the NAS."

3.4 Enterprise architecture frameworks

Several websites were visited and documents read which describe the history and content of various architectural frameworks. The analysis looked at the theoretical beginnings of architectural framework schemes, such as the Zachman framework, but the main focus was on two more recent tailored manifestations of this paradigm, namely, the Department of Defense Architecture Framework (DODAF), formerly C4ISR, and the Federal Enterprise Architecture Framework (FEAF).

These frameworks have resulted from federal government mandates for all of its agencies to use common process and products in the development of information architectures. A few documents were found which make comparisons between these frameworks, thus providing a basis for an assessment of the likelihood for architectures produced under these frameworks to be interoperable.

Architecture frameworks will be an important influence in the future development of government agency information technology acquisition and development strategies. In fact, the C4ISR architecture framework (and its successor, the DODAF) has been used in formulating information architectures within the military for almost a decade.

We found little evidence of any similar work on the civilian side using FEAF. However, the legislation driving this transformation will affect both civilian and military organizations and how they share information. From the viewpoint of future interoperability between civilian and military information architectures, it is prudent to understand what enterprise frameworks for architecture development are.

It is important to understand that the subject of discussion in this section is *architecture frameworks*, not actual *data architectures*. These frameworks establish the common *processes* which all government agencies must use and *products* they must produce when designing information architectures. This makes it easier to track and quantify progress and to show compatibility with other systems designed under the same framework.

3.4.1 Introduction

The growth in the size and complexity of federal government agencies, with the accompanying inefficiencies, cost overruns, performance lapses and lack of customer support has prompted public and congressional demand for more efficient and accountable practices.

Two US government legislative acts in the 1990's attempt to remedy this situation. One is the Information Technology Management Reform Act (ITMRA), also called the Clinger-Cohen Act of 1996, which requires all government agencies to streamline IT acquisitions and emphasize life cycle management of IT as a capital investment. This legislation places emphasis on interoperable, integrated and cost-effective business practices and capabilities, particularly with respect to information technology (IT).

The other is the Government Performance and Results Act (GPRA) of 1993, which requires all government agencies to set goals and measure performance against those goals, focus on results, service quality and customer satisfaction, and on improving tools to help achieve financial efficiency.

A related document, *Executive Guide: Improving Mission Performance Through Strategic Information Management and Technology* (Other Written Prod., 05/01/94, GAO/AIMD-94-115), provides 11 guidelines or rules for achieving the goals of this legislation. Rule number 6 states:

Focus on process improvement in the context of an architecture.

The linkage is therefore made between the legislation and the concept of an "architectural framework", which is intended to function as a common reference for developing, designing, implementing and assessing the performance of complex systems. Some of the goals are to improve coordination and communication within and between government agencies by encouraging the use of procedures and practices based on a common set of guidelines and rules.

3.4.2 Genealogy of Architectural Frameworks

In Figure 1 (from Ref. [17]), some of the main common architecture efforts of the past 20 years are shown. The branch on the right, which includes C4ISR and DoDAF, refers primarily to DoD efforts. The branch on the left, starting with the Zachman framework and culminating in the TEAF is directed mainly at civilian government agencies. In this document, we ignore the TEAF in favor of the FEAF, since the TEAF is concerned specifically with the Treasury department, while the FEAF is more generic.

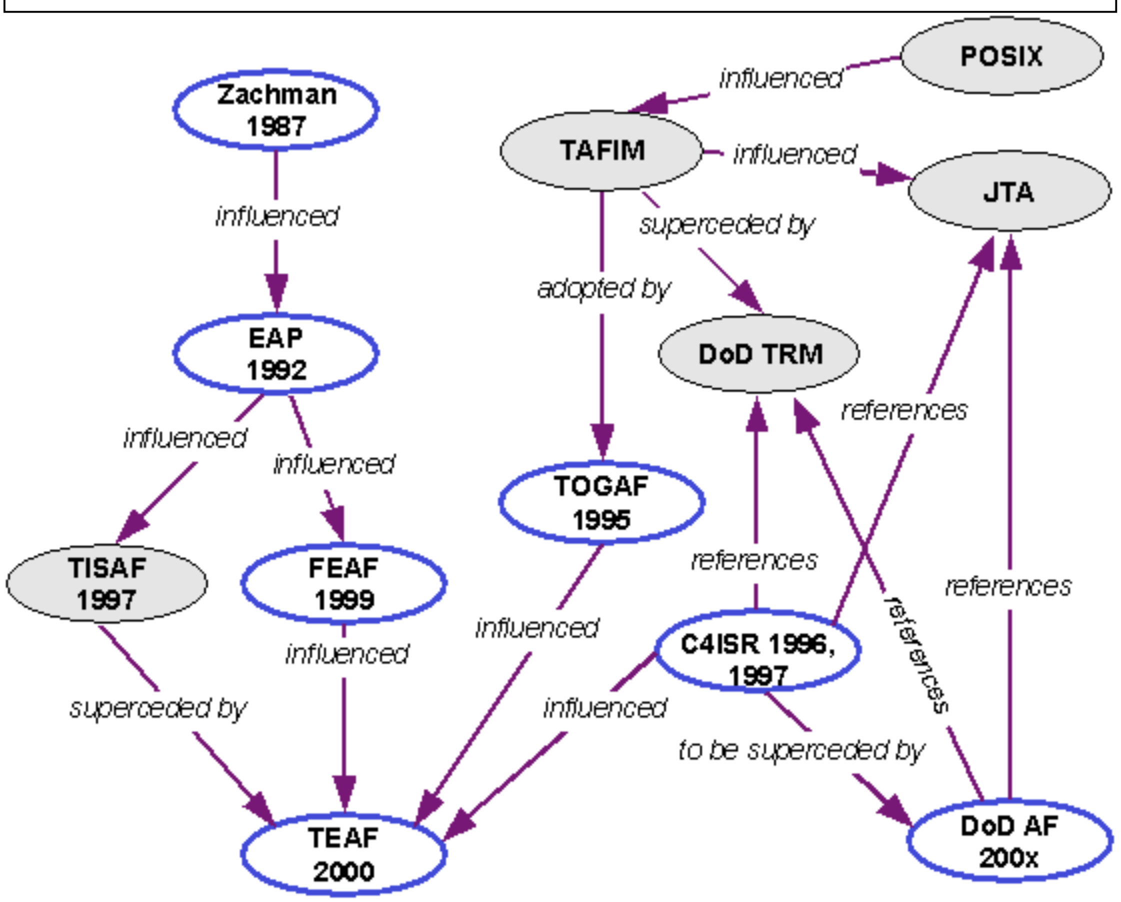
The diagram in Figure 1 seems to show that the DoD and civilian efforts have diverged. Fortunately, none of this work was performed in a vacuum, and ideas almost certainly flowed informally from one domain to the other. Also, both were probably influenced at some point in their development by the Zachman framework. The end result is a certain degree of commonality between DoDAF and FEAF.

However, there are significant differences in level of maturity, level of detail, and primary focus. Brief descriptions of each are given in the following sections, together with discussions of similarities and differences.

3.4.3 Zachman Framework

In 1987, John Zachman published the Zachman Framework for Enterprise Architecture. See Ref. [18] for a description and further links. He wrote "To keep the business from disintegrating, the concept of information systems architecture is becoming less of an option and more of a necessity." With this belief, he created the ZIFA. This organization is a network of information professionals who understand the value of EA for organizations participating in today's global economy. The mission of ZIFA is to promote the exchange of knowledge and experience in the use, implementation, and advancement of the Zachman Framework for Enterprise Architecture. This framework is used most

Figure 1. Enterprise Architecture Framework Evolution



frequently for business and industry information systems.

The Zachman framework is influenced by principles of classical architecture that establish a common vocabulary and set of perspectives for describing complex enterprise systems. This influence is reflected in the set of rules that govern an ordered set of relationships that are balanced and orthogonal. By designing a system according to these rules, the architect can be assured of a design that is clean, easy to understand, balanced, and complete in itself. Zachman's Framework provides the blueprint, or architecture, for an organization's information infrastructure.

The Zachman framework describes a holistic model of an enterprise's information infrastructure from six perspectives: planner, owner, designer, builder, subcontractor, and the working system. There is no guidance on sequence, process, or implementation of the framework. The focus is on ensuring that all aspects of an enterprise are well-organized and exhibit clear relationships that will ensure a complete system regardless of the order in which they are established.

A version of the Zachman framework is shown in Figure 2.

The meanings of the row labels are:
Scope. Corresponds to an executive summary for a planner who wants an estimate of the size, cost, and functionality of the system.
Enterprise model. Shows all the business entities and processes and how they interact.
System model. Used by a systems analyst who must determine the data elements and software functions that represent the business model.
Technology constrained model. Considers the constraints of tools, technology, and materials.
Detailed representations. Represent individual, independent modules that can be

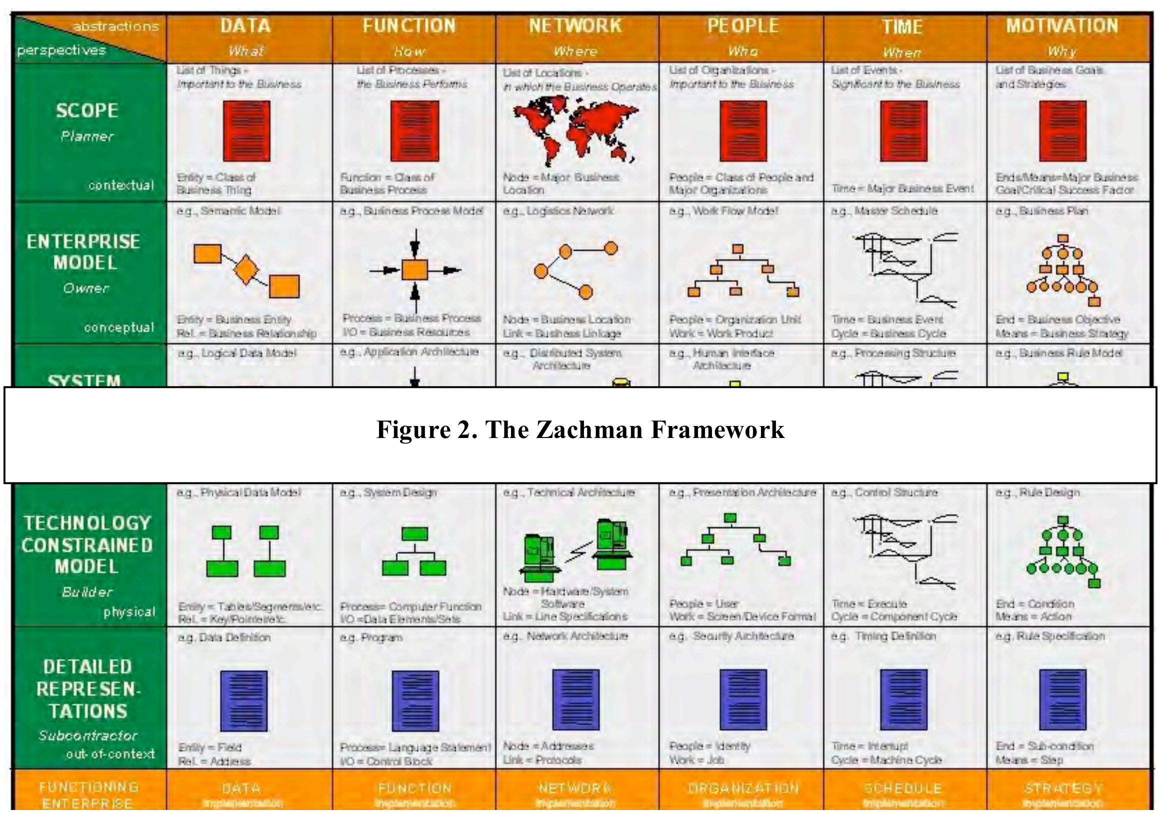


Figure 2. The Zachman Framework

allocated to contractors for implementation.
Note: Sometimes there is a sixth row, which shows the
Working system. Depicts the operational system.

The meanings of the column labels are:
Data (What). Describes the entities involved in each perspective of the enterprise. Examples include business objects, system data, relational tables, or field definitions.
Function (How). Shows the functions within each perspective. Examples include business processes, software application function, computer hardware function, and language control loop.
Network (Where). Shows locations and interconnections within the enterprise. This includes major business geographical locations, separate sections within a logistics network, allocation of system nodes, or even memory addresses within the system.
People (Who). Represents the people relationships within the enterprise. The design of the enterprise organization has to do with the allocation of work and the structure of authority and responsibility. The vertical dimension represents delegation of authority, and the horizontal represents the assignment of responsibility.
Time (When). Represents time, or the event relationships that establish performance criteria and quantitative levels for enterprise resources. This is useful for designing the master schedule, the processing architecture, control architecture, and timing devices.
Motivation (Why). Describes the motivations of the enterprise. This reveals the enterprise goals and objectives, business plan, knowledge architecture, and knowledge design.

3.4.4 Comparison of architecture frameworks

Some general conclusions were drawn from a thorough exploration of documents on the Internet concerning enterprise architecture frameworks:

- The C4ISR (DoDAF) has a longer "history" of development and application to DOD services than the does the FEAF as utilized by civilian government agencies
- The C4ISR (DoDAF) has more "maturity" and specific details concerning products and metrics to measure compliance
- The FEAF data model(s) are admittedly still in the future according to Government Computer News as of June 2004.
- The FEAF applications are still very business level oriented, with significant focus on inter-agency coordination and customer service.

Figure 3 shows a comparison view from the Enterprise Architecture Special Interest Group in 2003 (Ref. [15]):

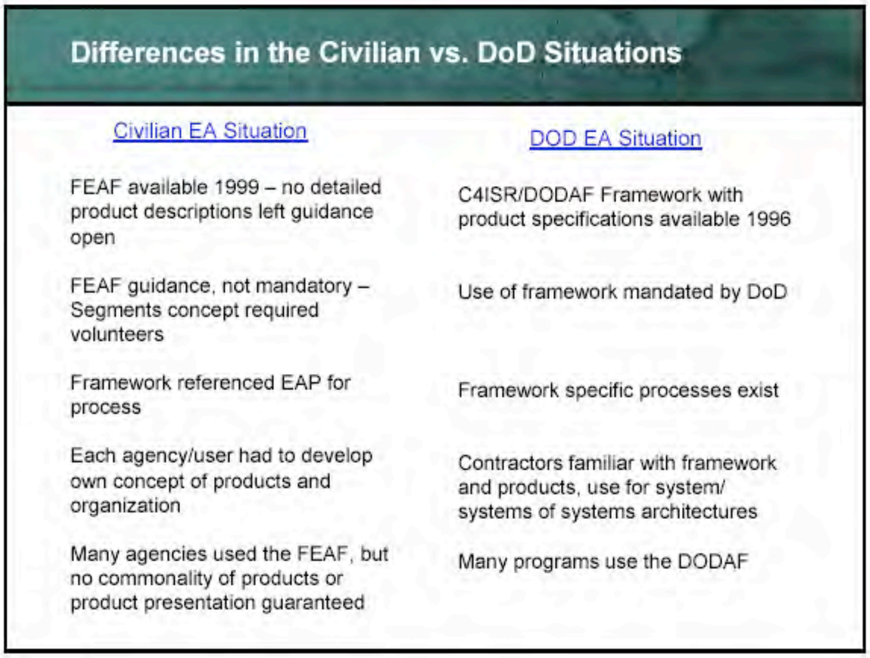


Figure 3 FEAF-DODAF Comparison from EA SIG

The following comparison discussion is taken from Ref. [16]:

"As shown by the color coding in Figure 4, the views and individual products of the *C4ISR Architecture Framework, Version 2.0* map to the cells of the Zachman Framework [Sowell, 1999]. (The figure maps only the most frequently-used DoD products, not all of them.)

Blue cells indicate that the *C4ISR Architecture Framework* contains operational view products that map to the cells; orange cells indicate that the *C4ISR Framework* contains systems products that map to the cells; and blue/orange cells indicate that the *C4ISR Framework* contains both operational and systems products that map to the cells. (Note that there are no red cells; this reflects the fact that no technical view products map to the Zachman Framework. This is because the Zachman Framework does not call for the explicit modeling of the applicable rules and standards themselves, but assumes standards to apply within multiple cells.)

Ovals have been overlaid onto the color-coded cells. These ovals represent individual products from the *C4ISR Architecture Framework* that correspond to the Zachman cell or cells onto which the oval is overlaid. Operational products are represented by blue ovals, and systems products by yellow or orange ovals.

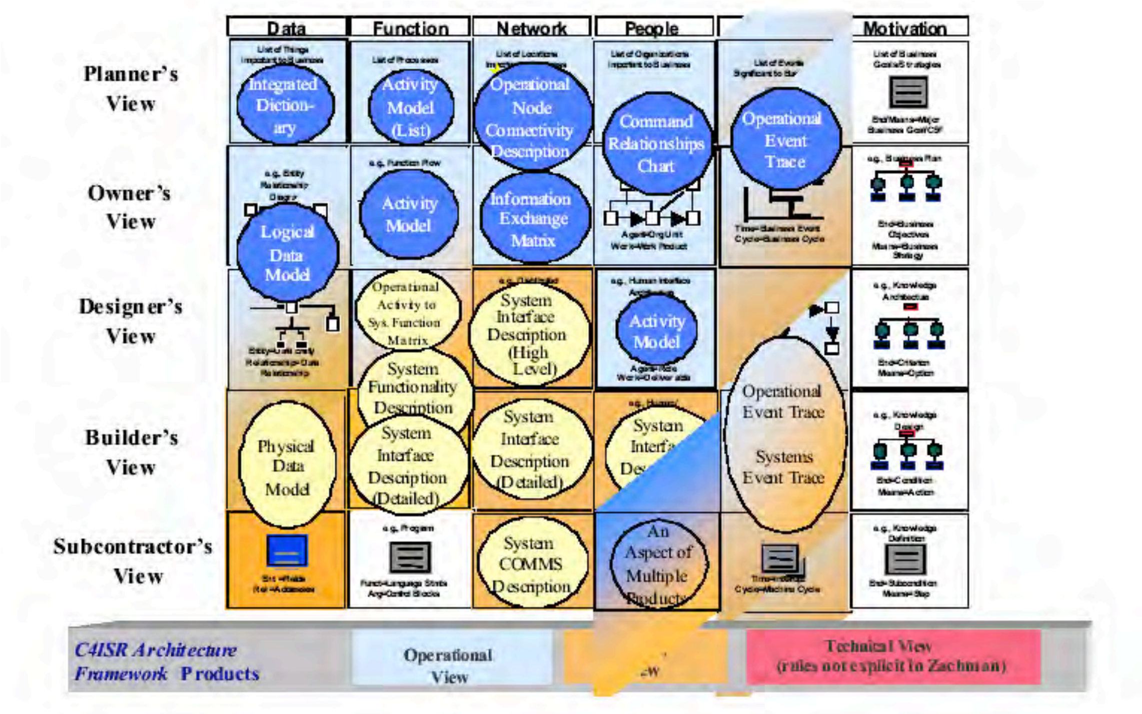


Figure 4 Selected DOD Framework Products Mapped to Zachman Framework Cells

Note that in some instances a cell is blue and orange, indicating that the *C4ISR Architecture Framework* contains both operational and systems products that correspond to the cell, but only a blue oval is shown in the cell. This is because not all the *C4ISR Architecture Framework* products are represented, only some of those that have been most frequently used in DoD architectures to date. The Function/Designer cell is blue and orange because the Operational Activity to Systems Function Matrix, while shown in the C4ISR Architecture Framework as a systems view product, is actually a pivot point between the operational and systems views.

Through this product-to-cell mapping, the *C4ISR Architecture Framework* can provide templates and guidelines for modeling the enterprise features that correspond to the Zachman cells.

Figure 5 illustrates the following correspondence between the FEAF components and the DoD Framework Views: the Business architecture roughly corresponds to the DoD's Operational View, the Design architecture roughly corresponds to the DoD's Systems View, and the FEAF's Standards roughly correspond to DoD's Technical View. (Data is distributed across the Operational and Systems Views in the DoD Framework.)

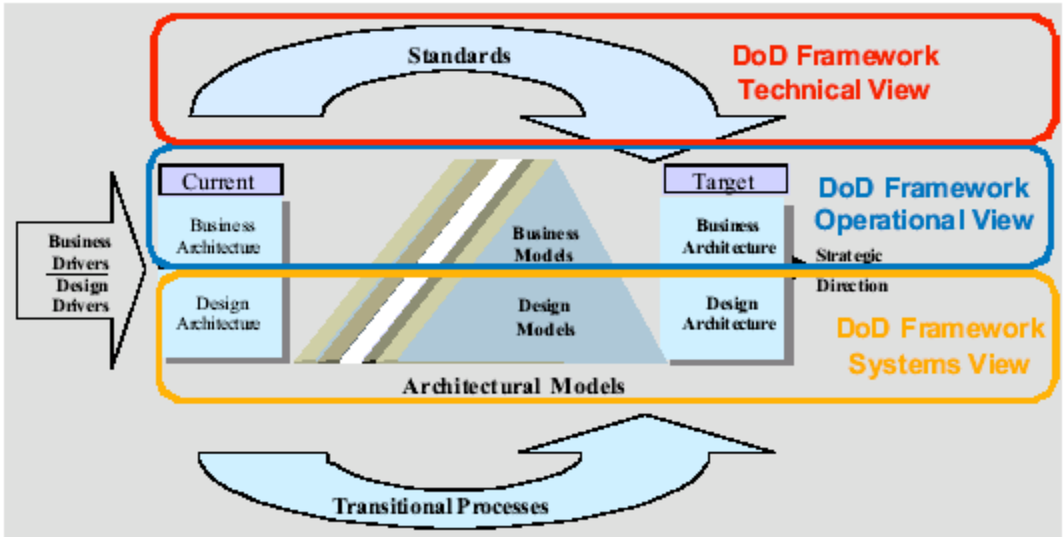


Figure 5 DOD Framework Views Mapped to Federal Framework Components

As stated above, the FEAF guidance is built on the foundation of the Zachman Framework, with the Spewak Enterprise Architecture Planning overlaid onto the first two rows. Because, as shown earlier, the DoD Framework products can be used to fill out the cells of the Zachman Framework, the DoD products can also be used to fill out the cells of the FEAF. Figure 6 illustrates the mapping of selected DoD Framework products to the corresponding cells of the FEAF. Note that the FEAF has made some modifications and annotations to the Zachman Framework rows and column names.

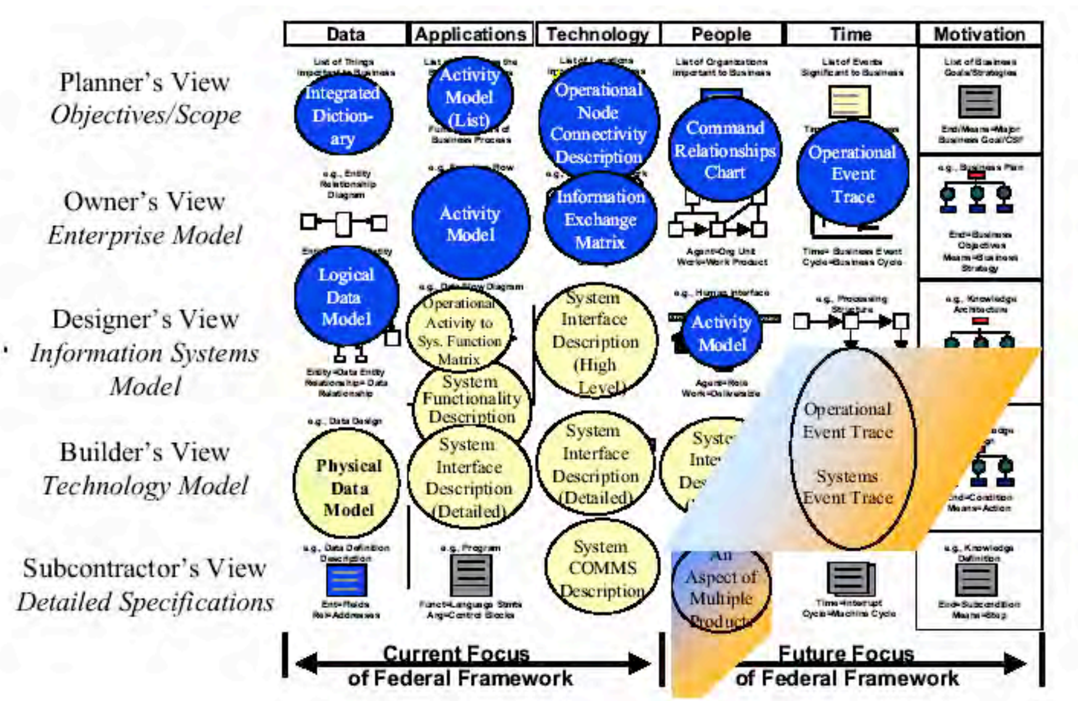


Figure 6 Selected DOD Product Types Mapped to Federal Framework Zachman-based Cells

Using the DoD Products in the FEAF: Federal Framework Pilot Architectures

The Federal CIO Council seeks to develop, maintain, and facilitate the implementation of the top-level enterprise architecture for the Federal enterprise. This architecture will serve as a reference point to facilitate the efficient and effective coordination of common business processes, information flows, systems, and investments among Federal agencies.

The approach taken to develop this Federal enterprise architecture is to develop architectures for selected high-priority cross-agency business lines, or "Federal Segments," which will collectively constitute the enterprise architecture.
With technical leadership provided by MITRE, a pilot effort is being conducted in which architecture descriptions will be constructed for one of the Federal Segments, to test the utility of the FEAF guidance. The candidate functional segment as of this writing is Grants.

There was concern within the Federal Agencies Information Architectures Working Group (FAIAWG) that the Zachman Framework did not provide enough detailed direction to enable a useful architecture analysis. At this point, the FAIWG turned to the *C4ISR Architecture Framework* products for this additional architecture information. Representatives of the FAIAWG worked with MITRE to examine the DoD products; they determined that the products were usable for the Federal Pilot with almost no modifications. Accordingly, four of the *C4ISR Architecture Framework*'s essential products and one supporting product will be used to populate the appropriate cells of the modified Zachman Framework.

The pilot effort will produce, in accordance with the *Federal Enterprise Architecture Framework* (as amended by the *DoD C4ISR Architecture Framework* products), a narrow-scope architecture pilot segment that can be used to gather lessons-learned for further development or improvement of the *Federal Enterprise Architecture Framework*. This effort will also support the activities of the Federal CIO Council's Emerging Information Technology and Interoperability Committee and contribute to the Committee's near term vision, which is *increased interoperability of Federal business processes to achieve a cost-effective, value-added contribution to the efficiency of the Federal enterprise*.

Figure 7 illustrates the products selected from DoD's Framework that will be used as templates for populating the Federal Framework cells selected for the Pilot [Sowell, 1999]. Although, as shown previously, many more DoD products map to the FEAF cells, only a few products were selected for a thin-thread example architecture for the Pilot.

Blue Text: C4ISR Framework Products

Shading = Products to be built in Pilot (No separate Activity Model; activities shown in Node Connectivity Description)

NOTE: C4ISR Architecture Framework's "All Views" products are needed by all cells!

Perspectives	Data Architecture (entities = what)	Applications Architecture (activities = how)	Technology Architecture (locations = where)
Planner s View Objectives/ Scope	List of Business Objects	List of Business Processes *Activity Model (Hierarchy of activities)*	List of Business Locations *Operational Node Connectivity -* • Major nodes only • Needlines not annotated
Owners View Enterprise Model	Semantic Model *Operational Information Exchange Matrix also contributes)*	Business Process Model	Business Logistics System *Op'nl Node Connectivity* • All nodes • Needlines annotated *Operational Information Exchange Matrix*
Designer's View Information Systems Model	Logical Data Model	Application Architecture	System Geographic Deployment *Sys. Interface Description (Internodal, System-to System)* *Technical Architecture Profile*
Builders View Technology Model	Physical Data Model	System Design	Technology Architecture
Subcontractors View Detailed Specifications	Data Definition "Library or Encyclopedia"	Programs "Supporting S/W Components"	Network Architecture

Figure 7 DOD Framework Products Mapped to the Federal Pilot architecture Models

Note that the Technical Architecture Profile does not actually map to the FEAF cells, because "Standards" are not explicit in the FEAF's modified Zachman Framework. It is included here for completeness of the Pilot."

4 Conclusions and Recommendations

4.1 Data Flows in the NAS

Based on the exercise of constructing the data table from APPENDIX A: Data Flows in the NAS Spreadsheet, here is a summary of areas that deserve attention:

- Primary radar returns: An ROA may be sufficiently stealthy and/or physically small that its radar cross section (RCS) is insufficient to register on ATC primary radar. Primary radar is an important independent backup to secondary radar, which depends on the aircraft transponder signal.
- Secondary radar returns: Will ROAs equip with transponders? Without them, some vital information (id, altitude) will not be available to the ATC controller. In addition, this would be the only way to see ROAs that are "invisible" to primary radar. Hence, ROAs that are sufficiently stealthy to be invisible to primary radar would require a transponder, or other means of detection.
- Voice communications between the ROA pilot and the ATC controller: If voice link is via the ROA and a satellite, transmission latency may adversely affect controller workload. This is especially true in a busy airspace. The effect could be mitigated by a direct connection (say a telephone landline) between the AVCS and the ATC facility. But again, this introduces a novel procedure into the system,which could also cause additional delay. The direct ground connection might eliminate the "party-line" information used by pilots of manned aircraft in the vicinity of the ROA for situational awareness, depending on how the communication is implemented.
- Command and control of ROA: Again, if the link involves a satellite hop, the combined latency of the ATC controller→ROA pilot communication and the ROA pilot→ROA communication may become an issue for timely execution of ATC controller clearances.
- Display of real-time weather in the vicinity of the ROA: In an inhabited aircraft, the pilot can view adverse conditions on the cockpit weather display, if so equipped, or visually out the window, if there is sufficient visibility. This aids the pilot in avoiding dangerous weather conditions. The ROA pilot would be at a disadvantage in conditions of limited visibility, unless there is an appropriate onboard sensor (camera or radar?) and a weather display in the AVCS.
- Terrain and obstacle avoidance: Current populated aircraft of a certain size and/or capacity must have a Ground Proximity Warning System (GPWS), or as it is now called, a Terrain Avoidance Warning System (TAWS). The ATC ground control also has a Minimum Safe Altitude Warning (MSAW) system, which alerts the controller, who then advises the pilot. If TAWS becomes a requirement for ROAs, control link latency could again become an issue. Similarly for the time for the ROA pilot to effect a timely response to an MSAW-generated advisory from the ATC controller. One possible solution would be to send MSAW data directly to the AVCS; note that this strategy creates a new data flow.

- Pilot report: Pilots of manned aircraft are often asked to report turbulence or other weather conditions at their assigned altitude for the benefit of other users of the airspace. If this ability is also desirable for ROAs, there needs to be some way of detecting the relevant conditions. For turbulence, this might be strain gauges for sensing structural stress, or cameras suitably placed so that they would provide the pilot with “shaky” images.
- Navigation capabilities: As the NAS moves closer to “free flight” operational concepts, aircraft will need area navigation (RNAV) and appropriate Required Navigation Performance (RNP) capabilities. Will operators equip their ROAs in order to participate in these environments of the future? The tradeoff will be between the cost of equipage and the operational constraints imposed by non-compliance.
- Collision avoidance: The FAA currently does not allow ROAs to use TCAS (or ACAS, the official ICAO terminology) in restricted airspace. Several questions thus come to mind. Will ACAS be part of a “sense-and-avoid” strategy for ROAs? If so, will ROAs be allowed to make cooperative collision avoidance maneuvers? How will the current restriction on TCAS usage for ROAs be lifted?
- Equivalent level of safety (ELOS): The previous bulleted item is one part of the more comprehensive issue of achieving safety of flight for ROAs comparable to manned aircraft. This may involve new on-board and off-board systems, which implies new data flows.
- Surface movement: Navigating around a busy airport’s runways, taxiways and aprons will be a real challenge for an ROA. One of the technologies being explored for enhancing ground controllers situational awareness, called Airport Surface Detection Equipment (System)-Model X, or ASDE-X, will rely on radars and multi-lateration of transponder signals from the vehicles on the ground, as well as in the air. Again, the question is, will ROAs equip with transponders so as to participate in this environment? Also, what info can be presented to the ROA pilot to support ground operations?

4.2 NAS Modernization

4.2.1 Administrator’s Flight Plan

This is mainly an FAA mission statement, and is too high level to produce any observable implications for ROA impact on the NAS in terms of data modeling and sharing.

4.2.2 NAS Architecture Version 5

A *very* long list of operational improvements from the NAS Architecture Version 5 can found in Ref. [12]. Although a thorough analysis of all potential data issues was not made, a simple search of this list for “cockpit” revealed two on-board equipment items envisioned for the future air vehicle (presumably inhabited). They are listed below together with the operational improvements they would support. This would be a good area for follow-on work in the future.

- Cockpit Display of Traffic Information Avionics
    - Flight Information Service-Broadcast (FIS-B),
    - Traffic Information Service-Broadcast (TIS-B),
    - Terminal Weather Information,
    - Hazardous Weather Information,
    - Shared Responsibility for Horizontal Separation,
    - Aircraft to Terrain Separation,
    - All-Weather Surface Operations,
    - Domestic RNP Navigation,
    - Oceanic Satellite Navigation,
    - Low-Visibility Operations,
    - Enhance Traffic Advisories Using Digital Traffic Data,
- Next-Generation Air/Ground Communications System Cockpit Display Unit
    - Current NAS Status Advisory

4.2.3 OEP Version 6

Listed below are specific elements taken from the OEP (Ref. [8]) that either mention new types of data or operational changes that *may* affect the way data is produced or distributed. The items serve only as a starting point for discussion. Their inclusion does not necessarily mean that there will be a direct effect on ROA operations.

"Arrival/Departure Rate 4: Fill Gaps in Arrival and Departure Streams
Controllers and Traffic Management Coordinators (TMC) will have improved information on arrival and departure demand and on available capacity. Decision support tools will assist them in developing improved sequencing. These plans will reflect an improved ability to project the future position of the aircraft, to optimize use of runways and fixes, and to account for separation requirements based on aircraft weight classification. The results will be an improved balancing of airport runway assets and an increase in airport throughput rate for both arrivals and departures. In addition, the execution of the plan will be improved through the provision of tools that show controllers the delay required for each aircraft. Arrival metering will transition from being mileage-based to being time-based.

Arrival/Departure Rate 6: Coordinate for Efficient Surface Movement
1. Situational awareness for ground controllers
The establishment and distribution of real-time surface surveillance information will increase ground efficiency. Implementation of a seamless, real-time surface surveillance capability will reduce the range of uncertainty with regard to surface movement and resource demands.

For air traffic controllers, positive identification and accurate real-time position information for aircraft and surface vehicles will result in better and timelier decision-making for surface operations. Controllers will need to request fewer position reports and will be able to monitor and quickly identify aircraft exiting runways after landing or departing aircraft at the runway, for example. Access to this information will allow for

greater efficiency in taxiing and departure and ramp queue management, since the taxi path clearance can be tailored and monitored automatically to achieve throughput objectives. Planning and proactive control of surface traffic is made possible when controllers know the position of aircraft before initial communication/contact is made.

2. Queue information for tower and TRACON

Surface surveillance with positive identification of targets also provides the basis for developing accurate and automatically updated aircraft timelines for use by local Traffic Management specialists to optimize the flow of traffic to and from the surface. The real time availability of airport and runway queue information is also invaluable for operations in large TRACONS or where coordination of activities between multiple facilities is required. The generation of the information automatically ensures that it is timely and accurate.

3. Event information for Collaborative Decision Making (CDM)

For both Flight Operations Centers (FOCs) and Traffic Management Coordinators (TMCs), the availability of real-time surface surveillance information will support the development and implementation of applications designed expressly to improve traffic management and projections across all phases of flight. By adding information on both the individual flight movement and the aggregate flow on the surface, this knowledge can be incorporated more accurately into the operational planning and decision process, and done so more than 20 minutes sooner. The result is a vastly improved ability to project and identify periods of excess demand and other congestion. The more accurate, common situational awareness of the impacts across all phases of NAS operation will be directly reflected in more extensive CDM.

4. Surface Management Systems (SMS) to improve surface management and integrate the airborne arrival/departure flow initiatives

The availability of both surveillance and event information supports the development of SMS that can forecast queue, taxiway, and runway congestion. It will also provide alternatives for departure runway and taxi paths, as well as identify and offer queue ordering to meet departure and en route constraints that are part of other traffic flow initiatives.

<u>Airport Weather Conditions 1: Maintain Runway Use in Reduced Visibility</u>

The goals are to continue arrival rates at higher level as weather deteriorates from VMC to IMC by increasing instrument approach services and to introduce performance-based navigation requirements for all weather operations.

<u>Airport Weather Conditions 2: Space Closer to Visual Standards</u>

Use cockpit tools and displays to achieve Visual Meteorological Condition (VMC) throughput capacity in all weather conditions.

<u>Airport Weather Conditions 3: Reconfigure Airports Efficiently</u>

Provide timely information about hazardous weather conditions and changes in wind conditions.

Airport Weather Conditions 4: Enhanced All-Weather Surface Operations
Provide airport surface situational awareness in low visibility conditions.

Enroute Congestion 3: Reduce Voice Communication
Use Aeronautical Data Link System (ADLS) and Controller-Pilot Data Link Communications (CPDLC) to reduce dependence on voice communication."

4.2.4 Target System Description

Many new systems and technologies are being proposed as part of TSD (Ref. [10]). The ones which have implications for new types of data and/or ways of producing, processing or transmitting that data include:

- Flight Object Management System (FOMS)
- Aeronautical Information Management (AIM)
- System Wide Information Management (SWIM)
- Communication Management System (CMS)
- Automatic Dependent Surveillance-Broadcast (ADS-B)
- Traffic Information Service-Broadcast (TIS-B)
- Flight Information Service-Broadcast (FIS-B)
- Surveillance Data Network (SDN) (may be intended only for controllers, HS, other agencies on the ground)
- General Weather Processor (GWP)

Although SWIM is discussed in the next section, a good follow-on project would be to look more carefully at the other technologies listed above.

4.2.5 SWIM

The System Wide Information Management System concept is no less than a revolutionary transformation of the NAS information system. At this point it is still a concept, and many details of the architecture have not been developed. One of the primary elements of the proposal is the "publish-subscribe" paradigm, in which producers of data "publish" it on a network, and users of the data can "subscribe" to it by extracting suitably tailored versions of the data. Many issues associated with this paradigm will be have to be addressed, such as latency, integrity, and security.

This area certainly bears watching, but it is difficult to make more detailed statements at this time about the interaction with ROAs.

4.3 Data Schemas

Given that this is an area under active development, with many uncertainties about future direction on both sides of the Atlantic, it is difficult to make definite statements about

data object compatibility and management at this time. Some more research and discussion with domain experts is needed.

4.4 Enterprise Architecture Frameworks

Although it seems obvious from the name, it is important enough to repeat that these are *architecture frameworks*, not actual *data architectures*. A *framework* only sets out the required *processes* and *products* of the architecture development.

Given that no examples were found of data architectures developed under the FEAF, it is impossible to compare interoperability between FEAF-developed architectures and DODAF-developed architectures.

However, it is also clear that there are strong similarities between the two frameworks, and if they are both applied rigorously, they should produce interoperable architectures. More future work could look at actual architectures produced by these frameworks, if and when the ones on the civilian side become available.

APPENDICES

APPENDIX A: Data Flows in the NAS Spreadsheet

Data Category	Data Description	Remarks	Information Attributes
Weather	Data about atmospheric or meteorological conditions.		**Data**
			Function
			Network
Surveillance	Data about the actual locations of aircraft and any surface vehicles, building and other non-meteorological obstructions to aircraft.	In some environments (e.g. oceanic/remote) this function may be partially achieved through knowledge of the vehicle's intent -- the flight plan.	**Transmission mode**
Aeronautical	Navigational (or other) data produced for pilots about the NAS airspace, NAS air traffic control system, and its assets. This includes airspace definitions, navigational communication aids and procedures, and changes thereto. This is long-term information which seldom changes.		**People**
ATM Resource Management	Data about the infrastructure assets of the NAS and their operational status or performance. Also, data used to negotiate, allocate or modify NAS airspace assets and associated airspace definitions. This refers to an up-to-the-minute status of NAS assets, such as a runway closure or a non-operating VOR.		**Automated Systems**

Operator Flight Recording	Performance data monitored and/or recorded by operator or other non-ATC agencies to help improve reliability, safety, maintenance, and training.	**Time**
ATC Flight Recording	Archived ETMS data for analysis. Flight data recorder (FDR) or cockpit voice recorder (CVR) data for incident investigation	**Motivation**
Strategic Flight Management	Data associated with entering flight plans or profiles into the system for purposes of long-term flow control	**Remarks**
Tactical Flight Management	Subsequent modification of flight plan for flow control purposes, for example, due to weather disturbances.	
Flight Control	Data (or voice transmisions) associated with short-term flow control, separation management or conflict avoidance. For example, ATC-pilot conversations about clearances.	

Description

Information that is transmitted and/or stored and must usually be processed to be useful. Includes voice and electronic or digital information.

Airspace services or activities which use this data

Nodes and direction of data flow from producer to user. May include automation systems as well as people.

Indicates how the information is transmitted. The two major categories are voice and electronic data. Sub-categories of voice are HF, UHF, and VHF. For data, examples would be mode C, mode S, VDL mode 2, VDL mode 4, UAT. This gives an indication of what equipage is required for compatibility.

Agents in the NAS that deal with this data, and perhaps make command and control decision based on the data and associated procedures.

Computer-based equipment which processes data for purposes of display, decision aid, archiving, etc. An example would be radar data processors which turn raw primary and secondary radar returns into a useful display for the ATC controller. Another example would be the Center TRACON Automation System (CTAS) which aids in flow planning and sequencing of aircraft entering a TRACON.

Can be a period of use, a latency requirement, a time horizon, or a perishibality period. A period of use might be "for the duration of the flight". A latency requirement bounds the time between the initiation of a transaction and its conclusion, for example, between a pilot clearance request and an ATC controlller response. A time horizon refers to the lead time needed for certain kinds of information, such as weather information to be used for flight planning. As an example of perishibility, let's say the ROA must pass a position report, and the position data in the reports is variable from 1s - 600s old, the data may be unsuitable for the intended purpose even if transfer times are very good (e.g. 1s).

Why is this data important to the user? Typical answers might be "for safe operation","for operational efficiency", "for maintanence purposes".

Further explains assumptions, reasoning or caveats. Might be a clarification question.

Data	Function	Network (Flow)	Transmission Mode
Primary Radar return	Situational awareness Independent surveillance	Radar -> Air vehicle -> Radar return processor -> Radar fusion processor -> Controller display	Electromagnetic radiation
Secondary Radar return*	Situational awareness Cooperative surveillance Dependent altitude verification	Radar -> Air vehicle -> Transponder -> Radar return processor -> Radar fusion processing - >Controller display	Transponder signals: 1030 MHz interrogate and 1090 MHz reply
Pilot report*	Situational awareness (for example, position, turbulence at altitude)	Pilot -> Controller -> Other pilots	VHF, UHF or HF depending on location.
Pilot-controller clearance conversation(s)*	Situational awareness	Pilot(s) <--> Controller(s)	
Controller observations (surface)*	Situational awareness	Controller eye -> Brain	
Multi-lateration sensor data*	Airport surface situational awareness	Transponder, radar transmissions -> Radar receivers -> Controller display	Radar pulses, transponder signals

ACAS traffic alert	Situational awareness	Aircraft -> Aircraft (Pilot)	Transponder signals
ACAS resolution advisory	Situational awareness Conflict resolution and collision avoidance	Aircraft -> Aircraft (Pilot)	Transponder signal
ADS-B message packet	Situational awareness Cooperative surveillance	Aircraft -> Aircraft or Aircraft -> Ground control	Competing modes: Universal Access Transmit (UAT), Mode S, or VDL Mode 4 (Europe only)
TIS-B message packet	Situational awareness Cooperative surveillance	Ground control -> Aircraft	
TAWS Data	Situational awareness (pilot) Avoidance of controlled flight into terrain (CFIT)	Terrain database, Flight computer -> Pilot	Electronic signals

MSAW/EMSAW Data*	Situational awareness (controller) Avoidance of controlled flight into terrain (CFIT)	Terrain database, trajectory computer -> controller display	Electronic signals
RAAS Data	Avoidance of controlled flight into terrain (CFIT)		
ASDE-X Data			

People	Automated Systems	Time	Motivation
Controllers	Computers that process data, correlate tracks, perform monioring and detection tasks	2-8 sec update rate	Monitoring for safety and conformance to flight plan (air vehicle)
Controllers, pilots (who can turn off the transponder)	Computers that process data, correlate tracks, perform monioring and detection tasks	2-8 sec update rate	Monitoring for safety and conformance to fligh plan (air vehicle)
Pilots, controllers		Seconds to minutes	Safety, comfort (air vehicle)
Pilots, controllers		Seconds to minutes	Safety (air vehicle)
Controllers		Immediate	Monitoring for safety and efficiency in surface movements
Controllers	Computer systems that process and display raw radar and transponder returns	2-8 sec update rate (?)	Monitoring for safety and efficiency in surface movements

Pilots	ACAS data processing	Seconds to minutes	Safety (air vehicle) -- alerts pilot(s) to potential conflict several seconds in advance
Pilots	ACAS data processing	Approx 35 seconds before closest point of approach (CPA). See table to right for details about advisory time to CPA thresholds.	Safety (air vehicle) -- provides pilot(s) with instructions for evasive maneuver
Pilots, controllers		Milliseconds to seconds	Safety (air vehicle)
Pilots, controllers	Radar, transponder data processors and data fusion systems	Milliseconds to seconds	Safety (air vehicle)
Pilots	Computers that match aircraft position with ground and/or ground obstacles	Seconds	Safety

Controllers	Computers that match aircraft position with ground and/or ground obstacles	Seconds	Safety

Remarks

1. This category does not have star because an ROA may have a very small RCS that is difficult to detect with primary radar (some ROA's are purposely stealthy, for example).
2. Update rates vary according to airspace (generally 8s in en-route and 2-4s lower down). Here is a case where latency is not the right term. The latency is actually very short; the update rate comes from the sweep time for the radar head, or from the fusion processing.

1. The "*" for this category depends of course on the ROA being equipped with a transponder.
2.Update rates vary according to airspace (generally 8s in en-route and 2-4s lower down). Here is a case where latency is not the right term. The latency is actually very short; the update rate comes from the sweep time for the radar head, or from the fusion processing.
An ROA pilot can report turbulence only if there are on-board sensors (strain gauges, cameras) that can detect it.

Pilots listen in on "party line" for information on nearby aircraft

1. There are some general issues here, for example, when to activate/deactivate transponders,
2. There are equipage issues for ROAs, so as to be visible to surface multi-lateration systems.
3. The sensor here is either secondary radar or ADS-B or both

1. No "*" here because it is not clear that ROAs will equip with TCAS. The FAA does not even allow TCAS to be used by ROAs in controlled airspace.
2. Airborne Collision Avoidance System (ACAS) is the International Civil Aviation Authority (ICAO) terminology that includes TCAS. There are three types of ACAS; all of them are electronic systems put on board aircraft to help reduce the risk of mid-air collisions: ACAS I, ACAS II and ACAS III. Version 7.0 of TCAS II (Traffic Alert and Collision Avoidance System) is currently the only implementation that meets the worldwide ACAS II standards set by ICAO . TCAS II is produced by two manufacturors: Rockwell Collins and Honeywell.

3. TCAS will display different traffic symbols on the TCAS traffic displays. The type of symbol selected by TCAS is based on the intruder’s location and closing rate. The symbols change shape and color to represent increasing levels of urgency. An open diamond is a surveillance target beyond PA (Proximity Advisory) range. A PA symbol is a filled diamond that represents an intruder that is +/- 1,200 ft.
1. No "*" here because it is not clear that ROAs will equip with TCAS. The FAA does not even allow TCAS to be used by ROAs in controlled airspace.
2. Although both TCAS I and II will provide traffic alerts (TA's), only TCAS II (or ACAS) will deliver a resolution advisory (RA). TCAS II bases the alarms on a five second crew reaction time to achieve adequate separation.

Note: This technology is not in wide use yet. It has been studied in Alaska during the Capstone program, is used by some cargo carriers (UPS, for example). and there is a ground support network being tested on the East Coast. All current major airliners (Boeing and Airbus) come equipped with ADS-B transmit capability). The WP 3 team will come back to this in more detail in the FY'05 phase of our study when we look at future operations.

TIS-B includes data from all types of surveillance except pireps. It can be useful to equipped aircraft that are outside of traditional coverage.
Will ROAs equip with this capability? Will the database be on the ground or in the aircraft?
Terrain Awareness and Warning System (TAWS) is the new internationally accepted term for what was formerly known as Enhanced Ground Proximity Warning System or EGPWS, which has a terrain look-ahead capability. GPWS is a term used to apply to the first generation of TAWS equipment, which could only look straight down.

1. Normally this data goes to controllers, who must then warn pilots. In the case of ROAs, the control loop could be shortened considerably if this went straight to the ROA ground control station. THis would be a NEW data flow.
2. Minimum Safe Altitude Warning (MSAW) utilizes secondary surveillance radar (SSR) repsonses from aircraft transponders and trajectory tracking to determine whether it is likely that the aircraft may be exposed to an unacceptable risk of controlled flight into terrain (CFIT). MSAW is normally implemented locally within the radar display system software and compares predicted aircraft trajectories with a database of levels at which an alert will be triggered within specific geographic areas. The system is technically complex (due to need to compensate for radar processsing delays) and requires careful installation, commissioning and operation to ensure that false alert occurrences do not present a hazard to operations.

Europe vs. US

Europe may be ahead of US in fusion system development (ARTAS).

Europe may be ahead of US in fusion system development (ARTAS).

Both Europe and the US are pushing deployment of multi-lateration systems on the surface. ASDE-X in the US is currently in trials.


Own
Threshol
d
Threshol
d
Threshol
d
Threshol
d

Feet	TA Seconds	RA Seconds	TA NM lateral	RA NM lateral
0 - 500 Radio	20	Inhibited	0.1	Inhibited
501 - 2500 Radio	35	20	0.1	0.066
2501 - 10000 Baro	40	25	0.3	0.066
10001 - 20000 Baro	45	30	1	0.082
20001 - 30000 Baro	45	30	1	0.105
above 30000 Baro	45	30	1	0.122

Threshold	Threshold

Altitude	Altitude

TA	RA
Feet	Feet
1200	Inhibited
1200	300
1200	300
1200	300
1200	300
1200	300

Data	Function	Network (Flow)	Transmission Mode	People
Standard Briefing*	Go/No go decision and flight planning	FSS or NOAA WSO -> Pilot/FOC		Pilot, weather forecasters and briefers
Abbreviated Briefing*	Go/No go decision and flight planning with selected data	FSS or NOAA WSO -> Pilot/FOC		Pilot, weather forecasters and briefers
Outlook Briefing*	Long range flight planning (> 6 hours ahead)	FSS or NOAA WSO -> Pilot/FOC		Pilot, weather forecasters and briefers
Terminal Forecast*	Airport condition advisory	ASOS, ATIS, AWOS, selected navigation aids -> Pilot/FOC		Pilot

Automated Systems	Time	Motivation	Remarks
	Minutes to hours before departure	Safety (air vehicle)	Each row from 5 down is a component of one or more of 1-4.
	Minutes to hours before departure	Safety (air vehicle)	
	Minutes to hours before departure	Safety (air vehicle)	
	Issued 3 times a day, good for 24 hours	Safety (air vehicle)	Last 6 hours of 24-hr forecast includes expected conditions: VFR, MVFR, IFR, LIFR (sic) Note that ATIS does not give a forecast -- it's an actual, like METAR

Data	Function	Network (Flow)	Transmission Mode	People	Automated Systems
Flight object (flight profile, plan)*	Planning (commercial strategic)	AOC <--> Service provider	Electronic, telephone, in person	Flow planners, AOC	Operator computer, HOST computer
Flight object (flight profile, plan)*	Planning (military strategic)	Base Ops <--> Service provider	Electronic, telephone, in person	Flow planners, Base Ops	Military computer, HOST computer
Flight object (flight profile, plan)*	Planning (space launch strategic)	Service provider <--> Space launch company (?)	Electronic, telephone, in person	Flow Planners, Mission planners	Launch provider computer, HOST computer

Time	Motivation	Remarks
Pre-departure planning up to push-back clearance request	Efficiency (service provider); Meet demand (airline)	Flight object could be generated well in advance and populated as flight time approaches.
Pre-departure planning up to initial clearance request	Efficiency (service provider); Accomplish mission goals (military)	Flight object could be generated well in advance and populated as flight time approaches.
Pre-launch planning up to launch initiation	Minimize impact to system (service provider); Accomplish mission goals (space launch company)	Flight object could be generated well in advance and populated as flight time approaches.

Data	Function	Network (Flow)	Transmission Mode
Flight object (flight profile, plan)* (commercial tactical)	Planning	Service provider <--> Aircraft (sometimes AOC is in the loop)	
Flight object (flight profile, plan)* (military tactical)	Planning	Service provider <--> Aircraft	
Flight object (flight profile, plan)* (space launch tactical)	Planning	Service provider <--> Launch controller	
Flight object (flight profile, plan) (ROA tactical)	Planning	Service provider <--> ROA ground control	
Aircraft characteristics*	Tactical control and monitoring of aircraft	Computer database -> ATC controller	Electronic database retrieval.

People	Automated Systems	Time	Motivation
Controllers, Pilots, AOC		Push-back clearance request to end of flight	Efficiency and safety (service provider and airline)
Controllers, Pilots		Initial clearance request to mission review	Safety (service provider and military)
Controllers, Launch control		Launch to outer space (?)	Safety (service provider and space launch company)
Controllers, ROA pilot		Initial clearance request to mission review	Safety (service provider and the ROA company (?))
ATC controller	Flight Data Processors folks. These systems support the controllers, and use it to predict the a/c's progress through the airspace. This, in turn, is used to allocate ATC/M resources, plan sequences, deconflict traffic, etc. This information is of varying level of granularity and accuracy (from very poor to reasonable - never as good as the aircraft itself), depending on the ATC or ATM facility involved (and ATC vs. ATM is an important distinction here).	Seconds to minutes ?	Safety, efficiency

Remarks

Based on FCFS

Based on FCFS except for national defense, e.g.

Space launch has priority

Goal is to "file and fly".

That information the ATC controller needs to determine what he/she can ask of the vehicle. Based on conversations with former FAA personnel currently working for Boeing, this information (as stored in the ATC computers) is limited to aircraft type, whether it is a prop or a jet, and what its climb and descent rates are.

However, based on these same conversations, it appears there are other informal sources of information, such as scanned-in performance data, folklore ("the C-17 behaves like a 757"), and access to the Internet. But there is no uniform standard or requirement for detailed performance information. The flight plan has only very basic information.

1. Automation systems may need some of this information, but more detailed, say, as a function

Data	Function	Network (Flow)	Transmission Mode
Pilot-Controller Clearance Conversations*	Control (commercial tactical)	Service provider <--> Aircraft (sometimes AOC is in the loop)	
Pilot-Controller Clearance Conversations*	Control (military tactical)	Service provider <--> Aircraft	
Pilot-Controller Clearance Conversations*	Control (ROA tactical)	Service provider <--> ROA ground control	
Command and control inputs* (manned aircraft)	Conformance to flight plan, vehicle control and management	Pilot -> Air vehicle control system	Tactile, physical, electronic.
Command and control inputs (ROA)	Conformance to flight plan, vehicle control and management	Pilot -> Air vehicle control system	Line of sight (LOS) or SATCOM link.
Vehicle Sensor Data* (manned aircraft)	Situational awareness. Vehicle control and management (part of control loop).	Air vehicle sensors -> Pilot	Electronic.
Vehicle Sensor Data (ROA)	Situational awareness. Vehicle control and management (part of control loop)	Air vehicle sensors -> Pilot	Line of sight (LOS) or SATCOM link.

People	Automated Systems	Time	Motivation
Controllers, Pilots, AOC		Push-back clearance request to end of flight	Efficiency and safety (service provider and airline)
Controllers, Pilots		Initial clearance request to mission review	Safety (service provider and military)
Controllers, ROA pilot		Initial clearance request to mission review	Safety (service provider and the ROA company (?))
Pilot		Milliseconds	Safety and efficiency
Pilot	Flight control computers	Milliseconds to several seconds	Safety and efficiency
Pilot	Sensors, flight control computers	Milliseconds to Seconds	Safety, efficiency
Pilot	Sensors, flight control computers	Milliseconds to Seconds	Safety, efficiency

Remarks

Based on FCFS

Based on FCFS except for national defense, e.g.

Goal is to "file and fly".

The new element for an ROA is the (exterior) transmission link from the pilot to the air vehicle, which may give rise to unacceptable control loop delay.

The new element for an ROA is the (exterior) transmission link from the air vehicle to the pilot, which may give rise to unacceptable control loop delay.
Important issues will be
1. Standardization of ground control station,
2. Inclusion of certain "cockpit-like displays".

Data	Function	Network (Flow)	Transmission Mode
Notices to Airmen*	System used to provide updates on the status of the NAS	Service provider>pilots	
Aeronautical Information Plan*	Each nation is required to maintain all aeronautical information concerning their ATM system that is pertinent to those using it, e.g., communication links, airspace, instrument approach plates, etc..	Regulator -> Users	
1. Airspace Definitions*	Define classes of airspace and equipment requirements	ICAO -> CAAs -> Service providers and operators	
1a. Rules of the air*	Procedures developed by international/national regulatory bodies that establish operational procedures	ICAO -> CAAs -> Service providers and operators	
1b. Communications	Systems that provide links between operators and service providers for the transfer of information.	ICAO -> CAAs -> Service providers and operators	Land line telephone, SATCOM
1c. Approach Routes	Approach and landing	ICAO -> CAAs -> Service providers and operators	

1d. Navigation Aid Data*	Route navigation	ICAO -> CAAs -> Service providers and operators	
1e. Emergency Procedures*	Emergency response	ICAO -> CAAs -> Service providers and operators	
Letters of Agreement	Contracts between centers that specify the specifics of handoff procedures, for example.	Center <--> Center	Official documents.

People	Automated Systems	Time	Motivation
Service providers, pilots		Minutes to days prior to use of information. May stay current for months.	
Pilots, regulators	Electronic database (?)	Days to multi-years.	ICAO requires every member nation to provide this information, keep it updated, according to a global plan.
Airspace planners, service providers, air vehicle operators	HOST computer database (?)		
Airspace planners, service providers, air vehicle operators	HOST computer database (?)		
Pilots, controllers	HOST computer database (?)	2 sec (?)	
	HOST computer database (?)		

	HOST computer database (?)		
	HOST computer database (?)		
Flow planners, regulators, controllers, operators	HOST computer database (?)	Variable. Can exist several months to years without change, or may be modified quickly to fix a minor problem.	Efficiency and safety

Remarks

(1) Each ICAO region (9 of them) has their own individual implementation of the global plan.
(2) The current trend in ATC is to separate functions of regulation and provision of service. FAA is one of few organizations in world which still does both.
(3) Operators may be involved in developing the plans.
(4) Many changes occur irregularly based on circumstances and arrival of new information. Charting cycle is 56 days, for example.

Part of AIP.

Part of AIP.

Part of AIP.
There could be a latency issue for ROAs, if these operator-ATC comm links are used for critical data exchange.

May be an issue for ROAs if RNAV/RNPxx routes are used and ROAs are not RNAV/RNPxx capable.

Operators are not always advised of these agreements. This can be a problem for flight planning.

Data	Function	Network (Flow)	Transmission Mode	People
FOQA Data	Recording and analysis of critical flight data in the operation of aircraft	Aircraft --> Recorder --> Analysts, Training pilot, computer database (for reports)		Analysts, Training pilot, computer database
Aircraft status: On-board information*	Health management, cost containment, efficient maintenance	Vehicle sensor(s) -> Pilot/Operator	Electronic data link.	Pilot, operators, engineers, maintenance, engineering, training, record-keeping in FAA (certification)

Automated Systems	Time	Motivation	Remarks	
	From engine start to shutdown for collection. Various periods of time for analysis and training.	Flight safety, quality of training, adherence to procedures,	New ROA element: data must be sensed in ROA control center (inputs on ground rather than aboard aircraft) as well as ROA.	Recommend using AVCS (air vehicle control station) for ROA controller
Sensors and operator computer databses	Vehicle startup to shutdown	Safety, efficient resource utilization, achieve mission goals	Aircraft systems and performance data. This data goes to AOC, rather than ATC. Engine condition monitoring, which is automated and transmitted on some Boeing Commercial models, is used by the operator to support on-condition maintenance and replacement. It has been a successful strategy in that it has reduced the numbers of in-flight shut-downs and speeds unscheduled maintenance by having parts ready for an aircraft when it arrives at its destination.	

Data	Function	Network (Flow)	Transmission Mode
ETMS Data (archival)*	Analyze traffic flows in the NAS.	Volpe Center --> Analysts	Electronic
Flight Data Recorder (FDR) Data	Accident investigation	Vehicle sensors -> Recorder -> Investigator computers	Electronic
Cockpit Voice Recorder (CVR) Data	Accident investigation	Pilots -> Recorder -> Investigator tapes	Electronic

People	Automated Systems	Time	Motivation
Service Provider, Analysts	Days to hours	Capacity, efficiency	Validation of tools and models for traffic flow analysis and simulation.
NTSB	Sensors, recorder	Record for last 30 minutes (by continually writing over tape)	Safety
NTSB	Sensors, recorder	Record for last 30 minutes (by continually writing over tape)	Safety

Remarks

Data	Function	Network (Flow)	Transmission Mode
NOTAMS*	Announce temporary changes to the NAS	Service provider -> Operators & ATC controllers	
ETMS Data (real time: traffic surges, gaps, volumes)*	Manage traffic flow in the NAS.	ATCSCC -> Facility Traffic Managers / Controllers -> Operators / Pilots	
ETMS Data (archive)*	Non-real-time scheduling and flow analysis	ATCSCC -> Stakeholders	
SAMS/MAMS* Data	Sofware tools used to schedule SUA.	SUA manager <--> Traffic Manager -> Operators/ pilots	

Agents	Time	Motivation	Remarks
Service Provider, Operators/Pilots, ATC controllers	Days to hours	Safety	
Service Provider, operators/pilots	Days to hours	Capacity, efficiency	(1) Enhanced Traffic Management System. (2) Canada, Mexico, Europeans have similar systems, and information can be shared with U.S.
Service Provider, Stakeholders	Days years	Capacity, efficiency	Can be used to help improve airspace structure, scheduling algorithms, etc.
SUA Manager, Traffic Manager, operators, pilots	Hours to minutes	Safety and efficiency	Special use airspace tools (military and FAA). See FAA Order 7450.1 .

APPENDIX B: Current NAS Sensors and Systems and Data Attributes

From Ref [4].

Table B- 1: Surveillance Sensors/Systems

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic type	Data Attributes
ARTS	ASR-7,8,9; ASR-11; ATCBI; MODE-S	Surv-1	Surv: 128 bits	Surv: Custom Model Peak Loading: peak rate = 544 msgs/sec & avg rate = 70 msgs/sec Busy Loading: peak rate = 544 msgs/sec & avg. rate = 35 msgs/sec
STARS	ASR-7,8,9; ASR-11; ATCBI; MODE-S	Surv-1; Surv-3	Product Error Msg.: 112 bits Runway Config.: 192 bits	Uniform (constant) Product Error Msg.: 1 msg./min Runway Config.: 5 msgs/hr
HCS (w/PAMRI)	ASR-7,8,9; ASR-11; ATCBI; MODE-S	Surv-1; Surv-3	Product Error Msg.: 112 bits Runway Config.: 192 bits	Uniform (constant) Product Error Msg.: 1 msg./min Runway Config.: 5 msgs/hr
DARC	ASR-7,8,9; ASR-11; ATCBI; MODE-S	Surv-1; Surv-3	Product Error Msg.: 112 bits Runway Config.: 192 bits	Uniform (constant) Product Error Msg.: 1 msg./min Runway Config.: 5 msgs/hr
AMASS	ASDE-3; ASR-7,8,9; ASR-11;	Surv-1	Surv: 128 bits	Surv: Custom Model Peak Loading: peak rate = 544 msgs/sec & avg rate = 70 msgs/sec Busy Loading: peak rate = 544 msgs/sec & avg. rate = 35 msgs/sec
DBRITE TDU	DBRITE	Surv-7 (Aut-4)	DBRITE Display (data message): 704 bits VCU Data: 480 bits	DBRITE Display: Uniform (constant) VCU Data: Negative Binomial DBRITE Display (data message): 10/sec VCU Data: Peak: 2413 msgs/sec Avg: 1073 msgs/sec
STARS TDW	STARS	Surv-7 (Aut-4)	DBRITE Display (data message): 704 bits VCU Data: 480 bits	DBRITE Display: Uniform (constant) VCU Data: Negative Binomial DBRITE Display (data message): 10/sec VCU Data: Peak: 2413 msgs/sec Avg: 1073 msgs/sec
ASR-7,8,9	HCS, STARS, ARTS	Surv-9 (Surv-3)	Product Error Msg.: 112 bits	Uniform (constant) Product Error Msg.: 1

			Runway Config.: 192 bits	msg./min Runway Config.: 5 msgs/hr
ASR-11	HCS, STARS, ARTS	Surv-9 (Surv-3)	Product Error Msg.: 112 bits Runway Config.: 192 bits	Uniform (constant) Product Error Msg.: 1 msg./min Runway Config.: 5 msgs/hr
ARSR	HCS, STARS, ARTS	Surv-9 (Surv-3)	Product Error Msg.: 112 bits Runway Config.: 192 bits	Uniform (constant) Product Error Msg.: 1 msg./min Runway Config.: 5 msgs/hr

Table B- 2: Weather Sensors/Systems

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic Type	Data Attributes
NEXRAD Principal User processor	NWXRAD WSR- 88D	Wx-2	Lightening Detection Data: 152 bits	Uniform (constant) Lightening Detection Data: 1/min
NEXRAD WSR-88D	WARP Processor at ARTCC	Wx-2	Lightening Detection Data: 152 bits	Uniform (constant) Lightening Detection Data: 1/min
DSR	WARP Processor at ARTCC	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
URET CCLD	WARP Processor at ARTCC	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
CTAS /TMA	WARP Processor at ARTCC	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
CTAS WS	WJHTC (to be replaced by WARP)	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
AIS remote	AIS WS	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
AIS WS	AIS remote	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
ASOS	ADAS	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
US Customs	WARP Processor at ARTCC	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather:

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic Type	Data Attributes
				Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
HOST	ARINC/AFTN; AWP; ARSR; ASR-7,8,9; ASR-11	Wx-2	Lightening Detection Data: 152 bits	Uniform (constant) Lightening Detection Data: 1/min
STARS/ARTS	ARSR; ASR-7,8,9; ASR-11	Wx-2	Lightening Detection Data: 152 bits	Uniform (constant) Lightening Detection Data: 1/min
WMSCR	ARINC/AFTN; ADAS; AFSS FSDPS;	Wx-1, Wx-2		
ETMS WS & SD	ETMCC (Volpe)	Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
DOTS+	Kovouras; ETMCC (Volpe)	Wx-2	Lightening Detection Data: 152 bits	Uniform (constant) Lightening Detection Data: 1/min
AFTN/FIRs		Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
S1R/ODAPS		Wx-2, Wx-10		
ODAPS	WMSCR	Wx-2, Wx-10		
ITWS		Wx-1, Wx-10		
WARP FAABWTG (at ATCSCC)		Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
WARP Processor (at ARTCC)		Wx-1, Wx-10		
ADAS		Wx-1	Current surface wx obs: 1600 bits Hourly surface wx obs: 1600 bits Special surface wx obs: 1600	Uniform (constant) Current surface wx obs: 1/min Hourly surface wx obs: 137/hr Special surface wx obs: 10/hr
ARINC/SITA ODL Server		Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
ARINC Data Network		Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec
ATCT GSD		Wx-2	Lightening Detection Data: 152 bits	Uniform (constant) Lightening Detection Data: 1/min
TDWR		Wx-10	Weather: 64 bits	Weather: Negative Binomial Weather: Peak: 75 msgs/sec Busy (avg.): 15 msgs/sec

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic Type	Data Attributes
ATCT NEXRAD IDS		Wx-5	LLWAS Winds: 800 bits LLWAS Threshold Winds: 2400 bits	Uniform (constant) LLWAS Winds: 6/minute LLWAS Threshold Winds: 6/minute
ATCT ACE Control Cabinet		Wx-2, Wx-5		
Kavouris Receiver		Wx-4, Wx-5		
AFSS M1FC	ARTCC FSDPS	Wx-4, Wx-5		
FDP2000	ARTCC FSDPS	Wx-4, Wx-5		

Table B- 3: Flight Management Sensors/Systems

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic Type	Data Attributes
ETMS (ARTCC)	ETMCC, HOST	N/A		
ETMCC (Volpe)	ETMS	Traffic management computer to ARTS/HCS		
CTAS/TMA	HOST	N/A		
pFAST	CTAS/TMA	N/A		
HOST/DSR	CTAS/TMA, URET. CP DLC, ODAPS, OASIS, ARINC/AFTN, HOST, ARTS/STARS	HCS to ARTS; ARTS/HCS to Traffic management computer		
URET CCLD (Conflict Probe)	URET, HOST	N/A		
AIS WS	AIS Remote	AIS database download		
FDIO Remote Control Unit	HOST	Flight Data Input, Flight Data Output		
Host (via FDSPS)	HOST, DUAT/AFSS, FSDPS, MBO	Aut-2	Flight Data Acknowledgement: 264 bits ALNOT and IREQ Cancellations: 328 bits Flight Plan Closure: 400 bits ICAO Departure: 520 bits ALNOT and INREQ Responses: 928 bits Flight Notification: 1128 bits Flight Plan Disapprove: 2000 bits ICAO Filed Flight	Uniform (constant) Flight Data Acknowledgement: 1/hr ALNOT and IREQ Cancellations: 4/hr Flight Plan Closure: 129/hr ICAO Departure: 5/hr ALNOT and INREQ Responses: 3/hr Flight Notification: 129/hr Flight Plan Disapprove: 194/hr ICAO Filed Flight Plan: 15/hr ALNOT and INREQ: 5/hr Automatic Alert Message: 100/hr ICAO Aerodrome and

			Plan: 2304 bits ALNOT and INREQ: 6696 bits Automatic Alert Message: 80 bits ICAO Aerodrome and Radar Messages: 720 bits General Flight Service : 800 bits ICAO Synopses and Aircraft Reports: 720 bits General Information and Center Weather Advisory: 1600 bits ICAO Terminal Forecast: 1600 bits ICAO Route and Area Forecasts: 1600 bits ICAO Tabular Winds Forecast: 2160 bits ICAO Weather Warning/Advisories: 2400 bits	Radar Messages: 84/hr General Flight Service : 2/hr ICAO Synopses and Aircraft Reports: 71/day General Information and Center Weather Advisory: 138/day ICAO Terminal Forecast: 280/day ICAO Route and Area Forecasts: 4/day ICAO Tabular Winds Forecast: 28/day ICAO Weather Warning/Advisories: 2/day
WMSCR	ARINC/AFTN			
US Customs	ARTCC			
Oceanic S1R/TP Server	HOST			
NORAD TTY	ODAPS			
ODAPS	OFDPS	Flight Data Input		
FDP 2000	ARINC/SITA, DUAT/AFSS FSDPS	Flight Data Input, AUT-6	Law Enforcement Alert Cancellation: 824 bits Law Enforcement Alert: 1920 bits Law Enforcement Supplemental Alert: 2384 bits Military Operations Message: 480 bits NOTAMS: 280 bits PIREPS: 720 bits Weather Information Requests: 800 bits	Uniform (constant) Law Enforcement Alert Cancellation: 1/hr Law Enforcement Alert: 1/hr Law Enforcement Supplemental Alert: 1/hr Military Operations Message: 3/hr NOTAMS: 5/hr PIREPS: 11/hr Weather Information Requests: 560/hr
AIDCS	ARINC/SITA			
DOTS+	ARINC/SITA, ETMCC			
AWP	Airlines	Aut-3	DOD Surface Observations: 720 bits PIREPS, ICAO Radar Reports & ICAO Aerodrome Reports: 720 bits Processed NOTAMS: 1040 bits	Uniform (constant) DOD Surface Observations: 165/hr PIREPS, ICAO Radar Reports & ICAO Aerodrome Reports: 514/hr Processed NOTAMS: 165/hr

			AWOS Hourly Surface Wx Observation: 1600 bits NWS Amendments: 2700 bits NWS SIGMETS and AIRMETS: 4800 bits NWS Surface Observations: 39000 bits DOD Terminal Forecasts: 640 bits ICAO Aircraft Reports & Synopses: 720 bits Center Weather Advisory: 800 bits General Information & Meteorological Impact: 1600 bits ICAO Terminal Area Forecasts: 1600 bits ICAO Route and Area Forecasts: 1920 bits ICAO Tabular Winds Forecast: 2160 bits ICAO Weather Warning/Advisories: 2400 bits NWS Hurricane/Tropical Storm Advisory: 6400 bits NWS Area Forecasts: 9600 bits NWS Severe Wx Outlook: 12000 bits NWS Prognostic Map Discussion: 22400 bits NWS Terminal Forecasts: 284000 bits NWS Winds/Temperature Aloft Forecast: 460000 bits Airport Reservation Data: 176 bits AWOS Special Surface Wx Observations: 1600 bits DOD Hazardous Weather Information: 26400	AWOS Hourly Surface Wx Observation: 905/hr NWS Amendments: 107/hr NWS SIGMETS and AIRMETS: 5/hr NWS Surface Observations: 1/hr DOD Terminal Forecasts: 660/day ICAO Aircraft Reports & Synopses: 812/day Center Weather Advisory: 69/day General Information & Meteorological Impact: 138/day ICAO Terminal Area Forecasts: 280/day ICAO Route and Area Forecasts: 142/day ICAO Tabular Winds Forecast: 28/day ICAO Weather Warning/Advisories: 11/day NWS Hurricane/Tropical Storm Advisory: 3/day NWS Area Forecasts: 208/day NWS Severe Wx Outlook: 3/day NWS Prognostic Map Discussion: 4/day NWS Terminal Forecasts: 4/day NWS Winds/Temperature Aloft Forecast: 2/day Airport Reservation Data: 1000/hr AWOS Special Surface Wx Observations: 10/hr DOD Hazardous Weather Information: 2/day General Flight Service Message: 366/hr Law Enforcement Alert Cancellation: 5/hr Law Enforcement Alert: 5/hr Law Enforcement Supplemental Alert: 5/hr Military Operations Message: 65/hr NWS Weather Warnings and Advisories: 1/hr Traffic Management Advisories: 15/hr

			bits General Flight Service Message: 800 bits Law Enforcement Alert Cancellation: 720 bits Law Enforcement Alert: 1840 bits Law Enforcement Supplemental Alert: 2300 bits Military Operations Message: 480 bits NWS Weather Warnings and Advisories: 5600 bits Traffic Management Advisories: 5000	
STARS display	pFAST			
ARTS/STARS	HOST	ARTS to HCS		
TRACON EFSTS	ATCT EFSTS	N/A		
TRACON DSP	ATCT DSP	N/A		
ARINC/SITA	ATCT TDLS (PDC)	N/A		
ATCT TDLS (FDIO simulator)	ARINC/SITA, FDIO	N/A		
AMASS (TAIU)	ARTS	N/A		
DOTS+ (ATCSCC)	DOTS (Oceanic)	N/A		
AFSS M1FC Briefing Station	FSDPS	N/A		

Table B- 4: Aeronautical Systems/Sensors

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic type	Data Attributes
WMSCR	CNS			
AWP	WMSCR			
FSDPS	AWP, CNS	Aut-3	DOD Surface Observations: 720 bits PIREPS, ICAO Radar Reports & ICAO Aerodrome Reports: 720 bits Processed NOTAMS: 1040 bits AWOS Hourly Surface Wx Observation: 1600 bits NWS Amendments: 2700 bits NWS SIGMETS and AIRMETS: 4800 bits NWS Surface Observations:	Uniform (constant) DOD Surface Observations: 165/hr PIREPS, ICAO Radar Reports & ICAO Aerodrome Reports: 514/hr Processed NOTAMS: 165/hr AWOS Hourly Surface Wx Observation: 905/hr NWS Amendments: 107/hr NWS SIGMETS and AIRMETS: 5/hr NWS Surface Observations: 1/hr DOD Terminal Forecasts: 660/day ICAO Aircraft Reports &

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic type	Data Attributes
			39000 bits DOD Terminal Forecasts: 640 bits ICAO Aircraft Reports & Synopses: 720 bits Center Weather Advisory: 800 bits General Information & Meteorological Impact: 1600 bits ICAO Terminal Area Forecasts: 1600 bits ICAO Route and Area Forecasts: 1920 bits ICAO Tabular Winds Forecast: 2160 bits ICAO Weather Warning/Advisories: 2400 bits NWS Hurricane/Tropical Storm Advisory: 6400 bits NWS Area Forecasts: 9600 bits NWS Severe Wx Outlook: 12000 bits NWS Prognostic Map Discussion: 22400 bits NWS Terminal Forecasts: 284000 bits NWS Winds/Temperature Aloft Forecast: 460000 bits Airport Reservation Data: 176 bits AWOS Special Surface Wx Observations: 1600 bits DOD Hazardous Weather Information: 26400 bits General Flight Service Message: 800 bits Law Enforcement Alert Cancellation: 720 bits Law Enforcement	Synopses: 812/day Center Weather Advisory: 69/day General Information & Meteorological Impact: 138/day ICAO Terminal Area Forecasts: 280/day ICAO Route and Area Forecasts: 142/day ICAO Tabular Winds Forecast: 28/day ICAO Weather Warning/Advisories: 11/day NWS Hurricane/Tropical Storm Advisory: 3/day NWS Area Forecasts: 208/day NWS Severe Wx Outlook: 3/day NWS Prognostic Map Discussion: 4/day NWS Terminal Forecasts: 4/day NWS Winds/Temperature Aloft Forecast: 2/day Airport Reservation Data: 1000/hr AWOS Special Surface Wx Observations: 10/hr DOD Hazardous Weather Information: 2/day General Flight Service Message: 366/hr Law Enforcement Alert Cancellation: 5/hr Law Enforcement Alert: 5/hr Law Enforcement Supplemental Alert: 5/hr Military Operations Message: 65/hr NWS Weather Warnings and Advisories: 1/hr Traffic Management Advisories: 15/hr

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic type	Data Attributes
			Alert: 1840 bits Law Enforcement Supplemental Alert: 2300 bits Military Operations Message: 480 bits NWS Weather Warnings and Advisories: 5600 bits Traffic Management Advisories: 5000	
M1FC	FSDPS			
ISD4 or ACE/ISD	NOTAM Distribution Client			
NOTAM Distribution Client (NAIMES WS)	USNS Distribution Server			
SAMS Client	SAMS Server			
SAMS Server	SAMS Client			
ODAPS	WMSCR			
USNS Distribution Server	NOTAM Distribution Client			
Consolidated NOTAM System (CNS)	FSDPS, OASIS			
ATCT/TRACON Phone /fax	AFSS Phone/Fax			

Table B- 5: Resource Management Systems/Sensors

Automation/ Processing System (SINK)	Sensors feeding into System (SOURCE)	Traffic Model	Traffic type	Data Attributes
RMS Module	MPS	RMS to MPS		
MPS	RMS, MDT, MPS	MPS to RMS MPS to MPS		
NIMS Management Console	RMVC			
Remote Monitoring VORTAC Concentrator	NIMS Management Console			

APPENDIX C: Basics of the NAS

The Basics:

When you fly in the United States, you take it for granted that you will fly safely from place to place. What makes that possible?

Most people are familiar with the airport. They arrive and check in their baggage and themselves. They board the airplane and then sit back, relax and enjoy the ride.

Passengers arrive safely at their destinations, on time and ready to begin the next leg of their journey. They claim their baggage and leave the airport.

So what makes this happen? The NAS helps to make this happen. So what exactly is the NAS.

The NAS is a collection of systems, used by people, following certain procedures.

Passengers tend to experience only a small part of the total system, the airport. The airport is the most obvious part of the NAS. It visibly represents the hustle and bustle of the entire system. People and things moving from place to place.

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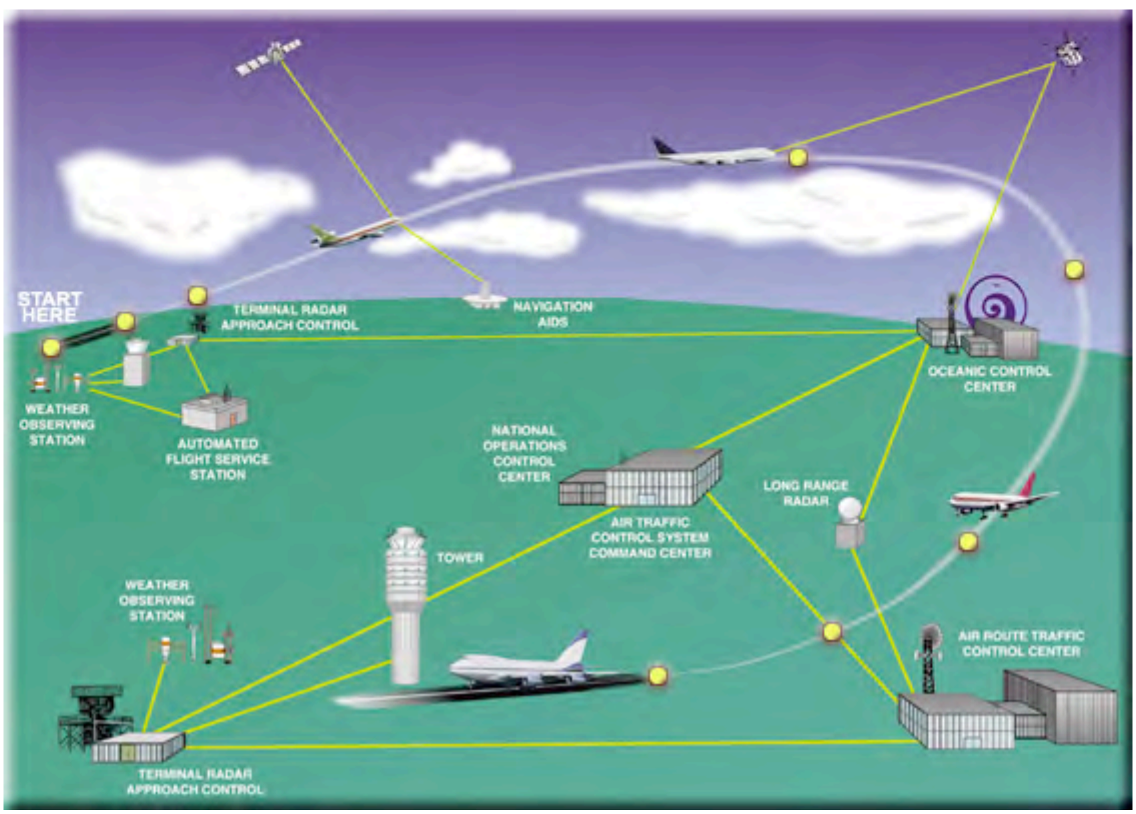
How does your Flight Work?



Ground Operations:

When you board an airplane, it is located on the ramp of an airport. This is the ground part of the NAS.

Air Traffic Control Tower:

The flight is under the supervision of the Air Traffic Control Tower until it is about 5 miles from the runway. The tower is the most recognized symbol of the NAS. The tower controllers are located in the glass booth you see at an airport at the top of the tower. When the pilot taxis the aircraft to the runway and departs the airport, the airborne part of the flight begins.

Departure:

Once the airplane is five miles beyond the airport, the control of the plane is transferred to the Terminal Radar Approach Control Facility (or TRACON). The TRACONs sequence and separate aircraft as they approach major metropolitan areas. There are over 185 TRACONs in the United States. TRACONs provide air traffic control services from just outside the airport to about 40 miles away.

Controllers and pilots are in constant communication. The controllers instruct the pilots on safe altitude, course and speeds to avoid other aircraft. Terminal controllers work with pilots to ensure the flight path is smooth and free of other traffic. The pilots acknowledge these directions and maneuver the airplanes safely.

En Route Airspace:

For most commercial flights, when the airplane departs the terminal airspace it enters the en route airspace. The way pilots get from one place to another is by highways, known as routes, in the sky. Some routes are primarily north and south, others run east to west. Various routes, or lanes, operate at different altitudes.

Twenty Air Route Traffic Control Centers (or ARTCCs) control and monitor airplanes over the continental United States and between airports. En route airspace extends beyond the United States coastline by approximately 100 miles and is bordered on the north by Canada and Mexico to the south. En route controllers work with pilots to ensure the flight path is smooth and free of other traffic.

Oceanic Control:

For flights over the ocean, United States controllers control the operations over part of the Atlantic, Pacific, and Arctic Oceans. These operations are very different from controlling aircraft over land. Once outside radar range, controllers must rely on periodic radio communications of position reports to determine the aircraft's location. The United States is responsible for almost 80 percent of the world's controlled oceanic airspace.

Arrival:

When a flight is approaching the airport, it descends from the en route or oceanic airspace into terminal airspace, where the TRACON controller efficiently sequences the airplane toward the runway. The tower controller ensures that the runway is clear for landing, the ground controller issues the instructions to get to the ramp where the ramp operators ensure the aircraft is quickly moved to the proper gate.

Flow Management:

Monitoring the entire operation is the David J. Hurley Air Traffic Control System Command Center ATCSCC), located in Herndon, Virginia. They receive an electronic picture of flights in the NAS from the ARTCC's across the country. The ATCSCC is responsible for ensuring the efficient use of all NAS resources through interaction with the FAA control facilities and airline

operations centers. This interaction allows the ATCSCC to develop guidelines, such as arrival/departure restrictions or alternative routings, to ensure that the operation of the NAS remains efficient. The exchange of information consists of equipment outages, congestion areas, and weather information to allow everyone including the users to participate in a collaborative decision making process for operating the NAS.

Airport:

There are about 3,300 airports in the United States that are considered significant to the capacity of the NAS. 413 of these airports are considered primary airports. These primary airports handle the vast majority of scheduled commercial flights. Each primary airport sees more than ten thousand passengers annually. The top 100 airports saw well over 500 million passengers in 1997 alone.

There are over 600,000 active pilots operating more than 280,000 aircraft. Aircraft include:

- commercial airplanes that carry people and cargo,
- small airplanes used by private pilots,
- helicopters, including those that are used for medical evacuation operations,
- business jets, and
- balloons and other craft.

Almost 30,000 FAA employees are actively involved with the monitoring and control of aircraft through the NAS. All these people, working together, result in safe, secure, and efficient flights.

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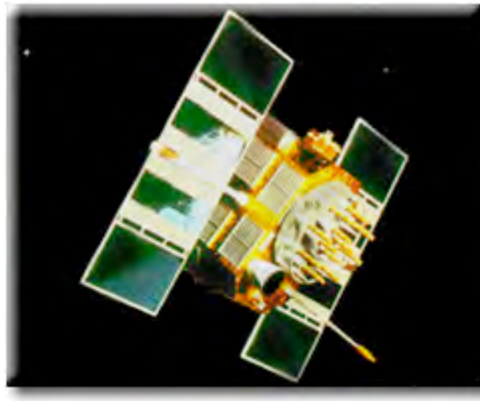
What makes the NAS work?

In each piece of airspace, many pieces of equipment must operate in harmony.

Navigational aids provide location signals to pilots. Each domain, or type of airspace, has unique requirements for precision. The accuracy needed to land in poor weather conditions is demanding. During the en route portion of a flight, navigational accuracy, although important, can be less precise.

The current NAS is based on a number of fixed routes, or highways in the sky. These routes are directly related to the ground-based navigational aids available to the pilot.

The western portion of United States has benefited from the removal of restrictions, which were based on these routes. Airplanes can now request direct (point-to-point) routes between certain locations. East of the Mississippi, there are more airplanes flying at any given time due to the proximity of major hubs to one another (for example, Philadelphia to New York, Washington to New York, Washington to Boston, etc.). Better accuracy of positions to both the controllers and pilots is required to safely ensure the removal of restrictions and allow more direct flights.



In an age where the Global Positioning System (GPS) is available for our cars, we should be using it for aviation as well. The currently approved navigational aids of the NAS do not take full advantage of GPS. The NAS, while very good, can be improved and flights can be made even safer through the use of augmented GPS.

Without radios, controllers and pilots would not be able to verbally communicate. On many flights, passengers can listen to the pilots and controllers. As the aircraft moves from one domain to another or from one sector to another, a new controller becomes responsible to monitor and control the flight. A sector (volume of airspace) is like county lines on a map extended upward in the sky. Each controller has the responsibility for the activity within one sector.

The current radios are based on the 1960's technology. Controllers and pilots can communicate some information without voice communications (initial clearance information, Pre-departure Clearance). Over the Pacific Ocean, we have established some non-verbal real time communication links, called Oceanic Data Link. However, most oceanic communications are relayed through a third person rather than using satellite technology.

There is no radar coverage over the ocean. Pilots must report their positions verbally or have them automatically sent through a relay station. The automation system acts like a big calculator and displays the position of the aircraft to the controllers. Because of the delays imposed by relaying communications, it is hard to accommodate requests for route and altitude changes over the ocean.

Oceanic Services Safely Meet Future Demand for Flights to Europe, Asia and the Pacific Rim

For the controller, surveillance equipment, primarily radar, detects the position of the many

rate of the radar antenna, varies by each domain of
nt of aircraft and other vehicles spin much faster
ninal airspace. The surface radars provide more

Surveillance or position information is processed by computers and displayed to the controllers on large computer screens. New tools to help the controllers

move more aircraft safely through the system have been developed. After years of research, these tools are now installed into some of the air traffic control facilities.

The controllers use automation tools (displays with computer processors and aviation software) to assist them with the tracking of aircraft. The aircraft submits a flight plan prior to take off. The automation systems monitor the progress of the flight with the radar information. The controller knows where the aircraft is located as well as where the aircraft is heading.

The current NAS is aging. Automation advances in recent years have been amazing. The enroute mainframe computers and the display system are being replaced now. All the terminal automation equipment is scheduled to be replaced. These older systems are not capable of accepting the new tools controllers need. Therefore these systems must be replaced.

Likewise, our telecommunication circuits have limited capacity and use old technology. These systems must be upgraded or replaced in order to meet demand for increased capacity.

Most NAS facilities were built in the 1950's. Some have been renovated. Many, though, need repair. Roofs leak. The power supply within the facility is unreliable. The buildings are too small. Access control is not compliant with federal law. Security is not adequate.

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What is being done to improve the NAS?

NAS Modernization has three key categories. The first category focuses on upgrading the infrastructure. The second category focuses on providing new safety features. The third category introduces new efficiency-oriented capabilities into the existing system. All the efforts associated with these three categories must be integrated. The evolution to a modernized NAS must be well orchestrated and balanced with the resources available.

New safety and efficiency capabilities require new tools and procedures, as well as training for controllers and pilots. But for the new tools to work efficiently, the infrastructure must be sound. This infrastructure includes buildings to securely and safely house the processors and displays for the controller. It also includes radar and radios. For the terminal area and many of the towers, STARS (the Standard Terminal Automation Replacement System,) is the key to the future. STARS will replace the displays and processors. It will provide a solid foundation for new capabilities.

For STARS to work successfully at many of the facilities it will be necessary to upgrade power systems and communication systems within the facility. Some facilities must be modified to be brought up to current standards for safety and security. In a few cases, structural repairs must be made before STARS can become operational.

Like our nation's highways, the facilities in the NAS are aging. Many of the Towers, TRACONs and ARTCCs need to be upgraded to meet current standards. OSHA standards, earthquake standards, power standards, and others have changed in the past 30 years. It is time for many of these significant repairs and upgrades to be accomplished at facilities housing our air traffic controllers.

Many facilities in the NAS house radios or other equipment. These too may need new roofs, more reliable or "cleaner" power, or a host of other facility modifications. It is crucial that we keep our NAS systems protected. Lost radar or communications signals can slow the flow of aircraft to a busy city. This may cause delays throughout the entire region, or possibly the whole country.

The second category for modernization activities focuses on the upgrades for safety.

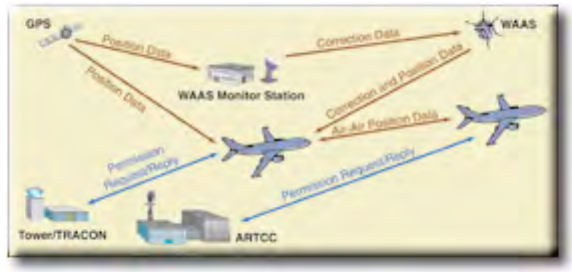
Weather has a big impact on the NAS. Fog in San Francisco, snow in Denver, thunderstorms in Kansas, wind in Chicago; all these reduce the safety and capacity of the NAS. Although we cannot control the weather, we are making great strides in being able to predict the weather. Controllers are receiving better information about winds and storms. The pilots are receiving better information before they take-off. All this makes flying safer.

Another cornerstone of the future for the FAA is improved navigational information available in the cockpit. The use of GPS will become more widely accepted. The Wide Area Augmentation System (or WAAS) will supplement GPS and provide pilots the accuracy they need for most flights.

This improved accuracy helps the pilots know their positions, which increases safety of flight. WAAS also enables improvements in efficiency, by providing access to more runways in poor weather, due to the precise navigation service it provides.

The Local Area Augmentation system (or LAAS) is being developed to provide even better accuracy than either GPS alone, or GPS with WAAS. LAAS will provide localized service for final approaches in poor weather conditions at major airports. Airports that require LAAS will be most of the top 100 airports in the United States and a few selected other locations that need the local signal due to other technical reasons.

This additional navigational accuracy that will be available in the cockpit will be used for other system enhancements. The Automatic Deptly (??) being evaluated by the FAA and airlines, takes advantage of this improved accuracy.

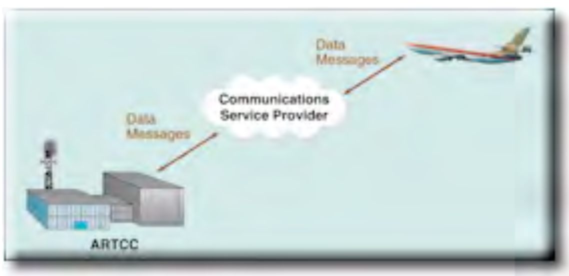


The ADS system will allow the aircraft to automatically transmit or "squitter" its location to various receivers. This "squitter" or broadcast mode is commonly referred to as ADS-B. The ADS-B signal can be received by other properly equipped aircraft. It also can be heard on the ground by receiver stations. The ground stations can then feed the automation system accurate aircraft position information. This more accurate information will be used to improve the efficiency of the system and is related to the third category of modernization activities.

New Procedures & Equipment Promote Fuel Efficient Flights

Other key efficiency improvements will be found in the deployment of new tools to assist the controller.

Over the ocean, most commercial aircraft already have equipment to send their GPS positions automatically to receiver stations. This is the key enhancement needed in all the oceanic airspace to allow more efficient use of airspace.



Improving text and graphical message exchange is the ultimate goal of the Controller Pilot Data Link Communications (CPDLC) Program. The first step is CPDLC Build 1. This step allows the FAA and pilots to understand how roles and responsibilities can change based on the increased exchange of information. This step will be conducted at Miami, and although the field test is still a few years off, preparations are under way by both the FAA and American Airlines.

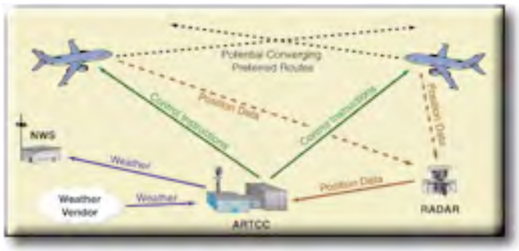
In the en route domain, DSR, the Display System Replacement, along with the Host/Oceanic Computer System Replacement, HOCSR, and Eunomia projects, are the platforms and infrastructure for the future. These provide new displays to the controllers and upgrade the computers to accept future tools, and provide modern surveillance and flight data processing capabilities. For CPDLC to work effectively, it must be integrated with the en route controllers' workstation.

We have begun to implement tools requested by the users through a project called Free Flight Phase 1. The National Civil Aviation Review Commission warned of impending gridlock at many of our major airports. Airlines say they will run into difficulties scheduling their flights without undue delays as early as 2005. We must expand airspace capabilities to meet growing demand.

FFP1

More than preventing gridlock, Free Flight Phase 1 provides the incremental steps the FAA needs to take to modernize the National Airspace System. There are five tools associated with

Free Flight Phase 1.



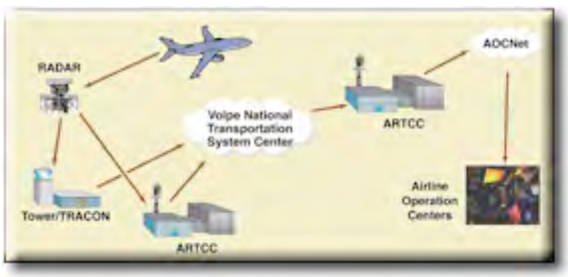
The User Request and Evaluation Tool (URET) is designed to help en route controllers predict the future flight path and identify potential conflicts. This tool helps controllers to allow planes to deviate from filed routes to avoid poor weather or to take advantage of favorable winds.

Another tool to be used in the ARTCC is called Traffic Management Advisor (or TMA). This tool assists traffic management specialists with developing arrival sequence plans for selected airports. Currently this tool is effective at airports that receive airplanes from one ARTCC.

Both URET and TMA will provide key improvements and are being implemented on a limited scale. These tools will help the aircraft fly a more direct route from point to point. And, both of these tools operate on the new en route displays.

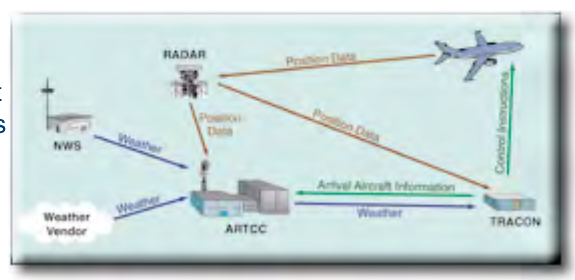
Improved Transition Between Airspace En Route and Terminal Airspace

Another key set of tool to ensuring that aircraft can arrive at their destination on time is Collaborative Decision-Making.



Collaborative Decision-Making, (known as CDM,) provides airline operation centers with real time access to information about the status of the NAS. This includes information about weather, equipment status, and known delays. With this information, the airlines, are able to better anticipate "trouble spots" and start to prepare contingency plans. Although this may not prevent a passenger from being delayed by poor weather at their destination, it does help airlines avoid stranding passengers and airplanes.

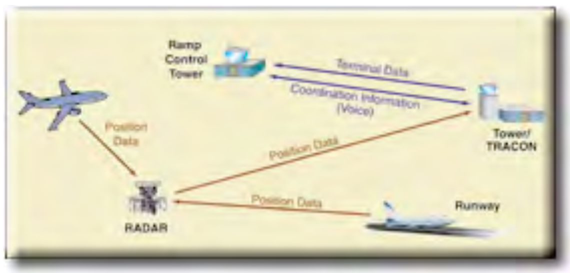
Improving operations around the airport is critical to most major airlines. Two tools are currently being tested to improve traffic flow around the airport. Both of these tools work with the Terminal Automation systems.



The first tool, pFAST (the passive final approach spacing tool) is used at the TRACON. It helps controllers sequence aircraft and assign runways based on user preferences and airport constraints.

Sharing of information is very important to the improvement of NAS operations. The second tool to improve operations near the airport

increases the sharing of information between the FAA and the airlines and is called SMA (or Surface Movement Advisor). The purpose of this tool is to provide information about arriving and departing aircraft to the airlines. Information, such as identifying the runway and the sequence for landing, enables the airline to plan better. This is most critical at hub airports when airplane turn-around times at the gate are closely scheduled.



APPENDIX D: Definitions

Air Vehicle Control Station (AVCS) - A site configured to allow a pilot in command of an ROA to operate and monitor all ROA operations conducted under his or her authority.

ATC Communications Link – Two-way data or voice link between the ROA system and the ATC system and/or other aircraft.

Command and Control (C2) Link – Two-way data link between the ROA pilot and the ROA that is used to control and monitor the health and status of the ROA.

High Altitude Long Endurance (HALE) ROA – An ROA capable of performing the mission objectives at an altitude of 40,000-foot mean sea level (MSL) or higher with sufficient cruise capability to transit the NAS.

Line of Sight (LOS) – The condition where the path between the air vehicle control station and the ROA form an unobstructed straight line.

Over the Horizon (OTH) – The condition where the air vehicle control station and the ROA are beyond line of site from each other.

Remotely Operated Aircraft (ROA) – An aircraft that is operated from a remote location by an operator that issues command and control instructions to the aircraft, which are executed near real-time by an onboard autonomous flight management control system.

APPENDIX E: Acronyms

ACAS	Airborne Collision Avoidance System
ADLS	
ADS-B	Airborne Dependent Surveillance-Broadcast
CDM	Collaborative Decision Making
C4ISR	Command, Control, Communications, Computers, Information, Surveillance, Reconnaissance
CPDLC	Controller Pilot Data Link Communication
DODAF	Department of Defense Architecture Framework
EGPWS	Enhanced Ground Proximity Warning System
FIS-B	Flight Information Service-Broadcast
FEAF	Federal Enterprise Architecture Framework
FDR	Federal Data Registry
FOC	Flight Operations Center
FOMS	Flight Object Management System
GPWS	Ground Proximity Warning System
IEC	International Electrotechnical Commission
ISO	International Standards Organization
IMC	Instrument Meteorological Conditions
OEP	Operational Evolution Plan
RNAV	Area Navigation
RNP	Required Navigation Performance
SDN	Surveillance Data Network
SWIM	System Wide Information Management
TAWS	Terrain Avoidance Warning System
TCAS	Traffic Collision Avoidance System
TIS-B	Traffic Information System-Broadcast
TMC	Traffic Management Coordinator
TSD	Target System Description
VMC	Visual Meteorological Conditions

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